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The Institute Papers. TAKEN as a whole, the papers read at the annual meeting of the American Institute of Electrical Engineers are eminently representative of the work which that body has set out to perform, and show conclusively not only that such a body is needed but, better still, that there is plenty of material in this country to be brought before such a society. The variety of the subjects discussed at the meeting is also an encouraging element, extending, as they did, from the eminently practical to the latest speculations upon the nature of electricity and magnetism, and their relation to each other. With such evidences of active interest taken in the Institute, it is safe to say that its future is well established, and that it will continue to be the medium of advanced electrical work and thought in this country. The many practical bearings of all the papers will not fail to attract the attention of the attentive reader.

Motor Regulation. IT has been remarked generally that there is no essential difference between a dynamo and a motor, and while this idea may be accepted broadly, the statement is not one which ought to be followed too closely in the designing of motors, by taking the dynamo as a standard. The difference is probably best illustrated by the paper presented by Mr. F. B. Crocker to the Institute, in which he has made a thorough analysis of the various types of motors and their methods of regulation, having regard to the different purposes for which they are intended. Mr. Crocker has rendered service to the profession by bringing together a valuable amount of information hitherto scattered, and to which the student as well as the designer frequently requires to refer. His analysis of the permissible as well as the impracticable forms of motors, taking into consideration various conditions which enter into their operation, points out the direction in which to work, and the paths to avoid.

Magnetism and Electricity. THE difficulties which present themselves in attempting to bring before an audience practical as well as theoretical considerations without accompanying apparatus for their demonstration, are brushed aside whenever Professor Thomson enunciates his ideas on any electrical subject, and the paper presented to the Institute this year is no exception to the rule. Professor Thomson delineated with beautiful clearness the relationship between magnetism and induced electromotive force and current, and showed how the nature of the magnetic circuit influenced this relationship. The practical considerations which he pointed out as following from these are most important and have a wide application, and a careful perusal of his paper will clear up the doubts that may exist in the minds of many on numerous points in the construction of dynamo-electric machinery generally and also many forms of alternating current apparatus. Professor Thomson's explanation of the phenomenon by which the alternating current is confined more to the surface of the conductor than to the interior is a beautiful demonstration, without the aid of mathematics, of this action, mysterious as it is to many persons.

Modern Views on Electricity. THE Institute meeting last week was brought to a fitting close by Prof. Rowland's admirable lecture on modern views of the nature of electricity and the experimental data which we have to sustain them. Naturally, a large portion of the lecturer's remarks related to the phenomena of electrical oscillations and the determination of the time and length of the waves as brought out by Dr. Hertz. Regarding the employment of these phenomena for practical purposes, Prof. Rowland disagrees with Prof. Lodge, who has attempted to apply them particularly to the construction of lightning rods, on the ground that the time period of oscillation of the laboratory apparatus is so short that it would be unsafe to generalize from the results obtained by it. On the subject of the transmission of the alternating current or oscillating discharge and its confinement to the outer surface of conductors, Prof. Rowland has, it seems, calculated simultaneously with, if not before, Sir William Thomson, the depth to which an alternating current penetrates a conductor, and he shows that in certain cases the current in the interior may be in a direction opposite to that at the surface, certainly a remarkable relationship.

The Electrical Engineering Profession. THE annual meeting of the American Institute of Electrical Engineers, held last week, was by far the most successful of any since the foundation of the society in 1884. The papers presented were numerous and valuable, the discussions were pertinent, and the attendance throughout was excellent. The Institute has always set itself a high standard, but it is living up to it in a manner that must fill all American electrical engineers with pride and encouragement, and that augurs well for the future of the profession. It is still young, but it has outlived the perils of youth, has won place and recognition solely on its work, and is evidently going forward also with the determination to do all that is in its power to secure for the electrical engineer as high a professional rank as can be secured in the country. There are many things for the Institute to carry out that have not yet been attempted, but every year what it does "still betters what is done," and exhibits a larger capacity for performance and a higher sense of responsibility. During the presidency of Mr. Edward Weston the Institute saw a marked increase in its influence and membership, and under Prof. Elihu Thomson it will enjoy no less measure of prosperity and success.

Popularising Electricity. WE hail with great pleasure as a sign of the times and as a proof of true journalistic enterprise and instinct, the beginning of the special series of articles on electricity in *Scribner's Magazine*. The first of the articles, by Prof. Brackett, appears this month, and its broad scope, combined with its scholarly treatment, warrants the belief that the series will be of unbounded benefit to electricity and to the community, which has become so eager for accurate and simple information on the fascinating subject. The publication of these articles will mark an epoch in American electrical development. They will not only stimulate the growth of electrical science and industry, but will excite a healthy interest in our art and profession throughout all classes, and will establish a bond of sympathy between those who employ electricity in its various utilitarian expressions and those who earn their living in the telegraph office, the telephone exchange or the dynamo room. As in the case of the Railway articles, it will be realized, thanks to the *Magazine*, that back of a huge and hitherto little understood industrial system are thousands of faithful, intelligent workers shaping to finer purposes and more perfect service one of the mightiest agencies of the day.

Storage Battery Train Lighting. IT is not so very long since that many, even among electricians, while admitting the success of the storage battery in stationary work, expressed serious doubts as to the practicability of their employment on board trains or street cars, owing to the supposed rough usage to which they would necessarily be subjected. A record of several years' trial, however, such as that presented in Mr. Alexander S. Brown's Institute paper, must dispel all doubt of their thorough reliability even under these trying circumstances. Mr. Brown by no means seeks to conceal the early troubles which were encountered in their use, but he now considers them entirely removed, and his paper, as that of one speaking for the railroads, may be said to confirm the claims of the storage battery as a means of train illumination. The discussion brought out by Mr. Brown's paper was of a highly interesting nature, and was well calculated to allay the fears of those who still consider the storage battery too weak to stand the wear and tear and jostle of a railway car. Several of those who took part in the discussion stated as the result of their experience that the jostling to which the cells are subjected not only does not injure them, but that, on the contrary, it prolongs their life. This is explained by the fact that the constant movement causes a continual circulation of the electrolyte, thus keeping it uniform throughout the cell and preventing injurious local action. This behavior of the storage battery must be considered specially favorable for its employment on street cars, in which the violent movements are far greater than in the case of railway trains.

Electrical Securities. IT seems to us that the remarks made by Mr. Erastus Wiman at the New York Electric Club last week, as to the difficulty he had experienced in raising money on his electrical stocks, are not altogether calculated to give the public the right and desirable impression. While Mr. Wiman was no doubt indulging simply in good humored joking, and partly at his own expense as an undiscriminating investor, the manner in which the newspapers printed his talk showed that the reporters did not see he was exaggerating in a rhetorical way to strengthen his point as to the desirability of a big electrical trust. Now it has yet to be proven that such a trust is desirable, and certainly if its merits were based only on Mr. Wiman's playful little argument, they would be few indeed. Besides, there are a great many electrical securities that are as good and as marketable as any other kind known to the world of finance. It is true that they are not all listed on the Stock Exchange of New York, but that might be said of a large number of other investments of a gilt-edged character. Such electrical stocks as are listed pay well, yet not so well as many utterly unknown to the average Wall street broker. The fact is that though telegraph and submarine cable stocks are a specialty in New York, telephone and electric light stocks are at least as popular in Boston and Chicago; while the stocks of local lighting companies and the bonds of electric railways are in brisk demand all over the country, particularly in their own respective localities. It stands to reason that an industry whose various branches already give direct employment to over 250,000 people must be tolerably substantial and profitable even if it has no "trust" in it. It has been suggested that why Mr. Wiman wants a "trust" is that he would at once unload his worthless, unpledgable stocks on it, but that is unfair to him. There is, moreover, an instructive side to his remark on over competition. We all know that competition in some of the later applications of electricity has run riot, so that not only has the business been, as he says, without profit, but development has been retarded by the poor work done. But those conditions are on the mend, and the improvement promises to go a long way.

Some Electrical Features of the Paris Exposition.

TEN days before the opening of the great exposition, writes our special correspondent in Paris, it was deemed highly improbable by the majority of persons visiting the grounds, that any kind of a show could be given on the sixth. The chief characteristic of the gardens was the slimy, greasy mud, which abounded on every side, reminding one of some of the streets of New York after a rain or thaw. Thousands of workmen were busily engaged setting up statuary, clearing away rubbish, planting trees and shrubbery, and doing the thousand and one things necessary to reduce chaos to good order. Pieces of the great electric fountain were lying about on every side, waiting to be put together. The work done on the third, fourth and fifth of May, metamorphosed the mud hole into a lovely garden, the walks of which were nicely graveled and lined on each side by trees and flowering plants. The 250,000 visitors on the opening day were delighted. Several band stands had been erected and the music from their occupants formed an additional attraction to the gay and festive throng. Everything looked beautifully, of course, but it was not until evening that the full scope of the preparations for the opening could be appreciated. The buildings and grounds were then in a perfect blaze of glory. The grand dome, decorated in azure and gold, was radiant with thousands of gas jets in festoons, wreaths and set figures, while the three sides of the hollow square occupied by the Palace of Industries, the Palace of Fine Arts and the Palace of Liberal Arts, were fairly ablaze with arc and incandescent lights, colored fire and Japanese lanterns. The Eiffel Tower stood out in bold relief against the dark sky, lit from top to bottom with red, white, and blue Greek fire. Four thousand lamps, of 4 candle-power each, supplied by the Continental Edison Company, outlined all the walks and flower beds, giving a fine effect to the grounds; while, through the lower arch of the tower, could be seen the Palais du Trocadéro, across the Seine, with its thousands of colored lanterns, fireworks, and two immense revolving search lights. What added most to the beauty of the scene, however, and attracted the most attention, was the electric fountain in the centre of the grounds between the Eiffel Tower and grand entrance, which gives some truly marvelous effects in color, and is the largest and most beautiful one of its sort ever erected. This grand fountain contains a very beautiful work of art, designed by M. Coutan, representing France surrounded by Science, Industry, Agriculture and Art, lighting the world by her torch. The lighting arrangements in the fountain proper are similar to those in the electric fountains at Staten Island, New York, Kensington Gardens, London, Glasgow and Barcelona, but on a much larger scale. Improved methods of directing and concentrating the light upon the water jets are employed, and the amount of water in motion is something tremendous. The central jet rises to a height of 100 feet, while the dozen or more auxiliary streams reach two-thirds as high. Under each set of jets is a chamber, very solidly constructed, with heavy plate glass directly under the jet, acting as a roof and protection from the fountain. In each of these chambers is an arc lamp of 6,000 candle power, a powerful parabolic reflector concentrating the horizontal beam of light upon a mirror placed at an angle of 45°, which reflects the light up through the changeable colored glass, the small plate glass roof and then through the jet of water above. In the cases where jets spring from horns of plenty in the sides of the basin, it became necessary to use a little more complicated arrangement for making the beam of light follow the line of the jet. Two concentric tubes are so arranged that the water flows between them, while the beam of light is thrown through the centre tube by means of a number of nicely adjusted mirrors. The chambers before mentioned are all connected together by subterranean passages, which find their outlet under the large piece of statuary of France and her torch. Here the operator can stand, and by a simple arrangement of levers, reminding one of the switch boxes and signal stations along our large railroads, some most beautiful combinations of light and water effects can be produced. Each jet can be independently operated or worked in connection with the others. For instance, the central jet can rise up to a height of 100 feet or more, and be of a brillant red, while half of the remaining jets can come to half that height and be of a dazzling white, those left looking like streams of blue fire. There is no limit to the number of combinations which can be made; red, blue, green, yellow, purple, white, one or all of these. Thousands of people gather nightly to watch the beautiful sight, and the expressions of delight heard on every side and in every language, show how this work of art is appreciated by the international gathering of visitors. The accompanying drawing shows the fountain at night.

Annual Meeting of the American Institute of Electrical Engineers.

The annual meeting of the Institute for the election of officers, reception of reports and the transaction of other business was held at the house of the American Society of Civil Engineers, 127 E. 23d street, on May 21 at 8 P. M.

The report of the Secretary, Mr. R. W. Pope, for the fifth year, showed that the Institute had a solid membership of 250 in good standing, and that the number was increasing at an average rate of about 5 per month; no fewer than 69 having been elected during the year, of whom 63 had qualified. The total number of Members and Associates on the books was 383. The report of the Treasurer, Mr. G. M. Phelps, showed receipts of $3,870 83 expenditures of $4,086.76, and a balance on hand of $44.32.

The accounts were audited by Messrs. Hamblet and Healy and were accepted.

The chair having appointed a nominating committee comprised of Messrs. Wheeler, Cuttriss and Stockbridge, to fill vacancies in the council, Dr. Wheeler reported a ticket, which was unanimously adopted. The subjoined shows the Board for 1889, the names of the new or re-elected officers appearing in italic: President, *Prof. Elihu Thomson*; Vice-Presidents, Francis R. Upton, T. Commerford Martin, *Edward Weston, Prof. Edward L. Nichols, Dr. Louis Duncan; Major O. E. Michaelis, U. S. A.;* Secretary, *Ralph W. Pope;* Treasurer, *George M. Phelps;* Managers Dr. Schuyler S. Wheeler, George B. Prescott, Jr., Joseph Wetzler, Thomas D. Lockwood, Francis B. Crocker, William Maver, Jr., John W. Howell, Charles Cuttriss, *Dr. F. Benedict Herzog, Henry Van Hoevenbergh, H. C. Townsend, Prof. W. E. Geyer.*

Dr. F. B. Herzog, as chairman of the Committee on Revision of the Constitution, made a brief viva voce report which led to a lively and interesting discussion on a number of points, such as the desirability of enlarging the Council, the need of a library, the dues for foreign members, the qualifications for membership, the method of electing officers, and the work of the Institute. These points are to be the subject of a full and careful report.

Mr. Edward Weston, the retiring president, touched upon the above topics in an earnest speech, and gracefully introduced his successor, Professor Thomson, who, on being escorted to the chair, spoke at some length and with much force on the opportunities before the Institute for work of benefit to electrical science and to the profession of electrical engineering. The meeting then adjourned.

The session for the reading of papers, etc., began at 10 A. M. on Wednesday at the same place, President Thomson in the chair, when the following papers were read and discussed:

"Some Results with Secondary Batteries in Train Lighting," by Alexander S. Brown, Pennsylvania Railroad.

"The Inherent Defects of Lead Storage Batteries," by Dr. Louis Duncan, Johns Hopkins University.

"Motor Regulation," by F. B. Crocker, Instructor in Electrical Engineering, Columbia College.

Adjournment of one hour was taken at 1 P. M. in order to partake of a collation provided in the library of the Civil Engineers, and a very enjoyable period of social intercourse was had, the gathering being large and representative. The afternoon session opened at 2 P. M., with Vice-President Weston in the chair, when the following papers were read:

"Magnetism and its Relation to Induced Electromotive Force and Current," by Prof. Elihu Thomson, Lynn, Mass.

"The Relation Between the Initial and the Average Efficiency of Incandescent Lamps," by W. H. Peirce, Chicago, Burlington & Quincy Railroad.

"The Efficiency of the Arc Lamp," with an introductory note by Prof. E. L. Nichols, by H. Nakano, Cornell University.

"The Spiral Coil Voltameter," by H. J. Ryan, Cornell University.

"The Personal Error in Photometry," by Prof. Edward L. Nichols, Cornell University.

The closing session was held at 8 P. M. at the College of the City of New York, in the lecture-room of Dr. R. Ogden Doremus, when Prof. H. A. Rowland, Ph. D., of Johns Hopkins University, delivered a lecture entitled, "Modern Views with Respect to the Nature of Electric Currents," illustrated by numerous experiments; and assisted by Mr. J. S. Ames. The room was crowded to overflowing, and the audience of about 350 persons included a large number of well-known men. There were present: Gen. Webb, president of the College; Drs. Ogden and Charles Doremus, Prof. Elihu Thomson, Mr. Edward Weston, Dr. Louis Duncan, Profs. Geyer, Nichols, Webb, Compton and Roberts, Drs. Herzog, Wheeler and Moses, Maj. O. E. Michaelis, U. S. A., Messrs. G. A. Hamilton, F. B. Crocker, C. G. Curtis, G. M. Phelps, R. W. Pope, W. H. Baker, E. P. Thompson, C. Cuttriss, Wm. Maver, Jr., G. B. Prescott, Jr., S. D. Greene, W M. Schlesinger, F. W. Child, F. E. Idell, J. Wetzler, T. C. Martin, H. L. Webb, E. T. Birdsall, J. Hamblet, C. L. Healy and many others. The lecture was well delivered, and was received most enthusiastically.

PARIS EXPOSITION: EIFFEL TOWER AND ELECTRIC FOUNTAIN BY NIGHT.

A Phonograph at the Gettysburg Panorama.

Edison's perfected phonograph amused the patrons of the Union Square Panorama Company on May 26. It reproduced from wax cylinders with wonderful accuracy a cornet solo by Levy, a banjo solo by Carter, an orchestral piece, Adonis Dixey's remarkable story of the discovery of America, and several songs. One of the cylinders had recorded the sounds made by a fife and drum, and the effect of this reproduction amid the vivid battle scenes of Gettysburg was realistic and impressive. Spectators were afforded an opportunity of experimenting with the marvelous invention. The exhibition was so successful that the management have decided to make the phonograph a standard feature of the show until further notice.

The Electric Plant on Board the "Augusta Victoria."

The dynamo room of the "Augusta Victoria," the new twin screw steamer of the Hamburg line, which arrived on May 19, presents a very pretty sight. Four engines of the Vulcan make run four Schuckert dynamos lighting the steamer with 800 16 c. p. Siemens & Halske lamps.

In the dining room, suspended from the ceiling, are a great number of little electroliers, containing three lamps each: the glass being opalescent, the effect is very fine.

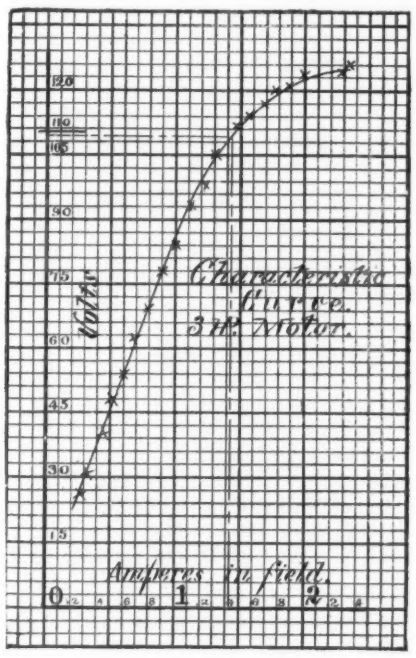


FIG. 2.—CHARACTERISTIC CURVE OF NEW C. & C. MOTOR.

Each state room is illuminated by a single lamp, suspended from the ceiling and encircled in a milk-glass globe, and having the appearance of a small arc lamp. Thirty ventilators of the latest pattern provide fresh air for passengers and add greatly to their comfort. These ventilators are run by the four engines that drive the dynamos. The dynamo switch board made by O. L. Rummer & Co., of Dresden, is a very elaborate and gorgeous piece of work. The dynamos are capable of delivering 300 ampères at 65 volts when driven at a speed of 450 revolutions per minute.

New Large C. & C. Motors.

The success which has from the start attended the introduction of the small C. & C. motor is well demonstrated by the fact that more than 3,600 of the ⅛ h. p. size have been built and sold. These motors were made in over thirty different designs and windings for different circuits and for special purposes. Besides these, over 500 one-quarter and one-half horse-power C. & C. motors have been built.

While the C. & C. Company have built motors up to 5 h. p. when occasion demanded them, they have not until recently had a complete set of standard motors from ½ h. p. up to 25 h. p. The shops having been crowded to their utmost to fill orders for small motors, no space was available in the old quarters to enter upon the manufacture of large motors as standard commercial machines. Upon moving into their new quarters work was immediately begun on a standard set of such machines, and Mr. L. W. Serrell, Jr., the electrician of the company, has designed these various sizes up to 25 h. p., all of which have already been built with the exception of the 20 and 25 h. p. motors, and are giving excellent satisfaction.

The general design of the motors is shown in the accompanying engraving, Fig. 1, made from a photograph of a 15 h. p. motor. The machines present a few peculiarities of construction. The field magnet cores are drop-forged from the best wrought iron, circular in shape and concentric with the shaft; they are oblong in cross section and of a width equal to the axial length of iron in the armature. When bolted to the base and pole pieces they completely surround the armature, forming an iron-clad machine. The armature is of the drum type and its general proportions are those of a Gramme ring in which the radial depth is increased until the annular ring reaches the shaft, forming a drum armature of large diameter. The general form of the machines makes it possible to reduce the amount of wire considerably, and the air space resistance between the pole piece and the iron in the armature is reduced to a minimum.

The windings were calculated by dealing with the magnetic circuit as if it were an ordinary electric circuit, following Ohm's law; magnetic potential corresponding to volts, the number of lines of force to current and the resistance of the iron when below saturation to the flow of lines of force, analogous to the resistance of a wire to the passage of a current. The circular form of machine gives the shortest possible length to the magnetic circuit. The number of turns of wire necessary to develop a certain number of volts at a certain speed were determined by knowing the number of lines of force an ampère foot of field wire would force through a magnetic circuit of a certain resistance.

Fig. 2 is the characteristic curve taken from a three h. p. 110 volt motor. The ordinates represent the volts generated in the armature, the abscissæ the ampères in field containing a certain number of feet of wire. The dotted ordinate is drawn at the point where the current flowing through the field produces the calculated number of ampère feet necessary to develop the 110 volts in the armature. The machine comes out remarkably close to the calculations, the actual number of volts developed being 109 against 110 as calculated.

These machines are constructed with great care to eliminate Foucault currents and undue heating. The friction load of a 15 h. p. 110 volt motor recently tested, running free, was only 440 watts, while the total energy consumed was 704 watts.

Economical Engines for Electric Light Stations.

BY F. H. BALL.

The *Stationary Engineer* for May gives an account of the first annual meeting of the New England Electric Exchange, and when I read the description of the new lighting station at Providence, given in the address of Mr. M. J. Perry, and there learned that the Reynolds-Corliss engine has been "proved to be the best type of engine made," and also that the difference was so great as to "leave the makers of other leading engines a wide margin for improvements;" when I read this I was sorry for the "makers of other leading engines," and I turned to the cover of the *Stationary Engineer*, and went over the list as there displayed, one by one, with a real feeling of sympathy.

I was particularly sorry for my friend Gardiner C. Sims, because, apparently, this fact had been "proven" right in Providence, where he lives, and where he is building what is supposed to be a pretty good engine. We are not told how this proof has been obtained, or when or where, but it seems to be no matter of opinion or conjecture, as it has been "proven," and that settles it. We are informed

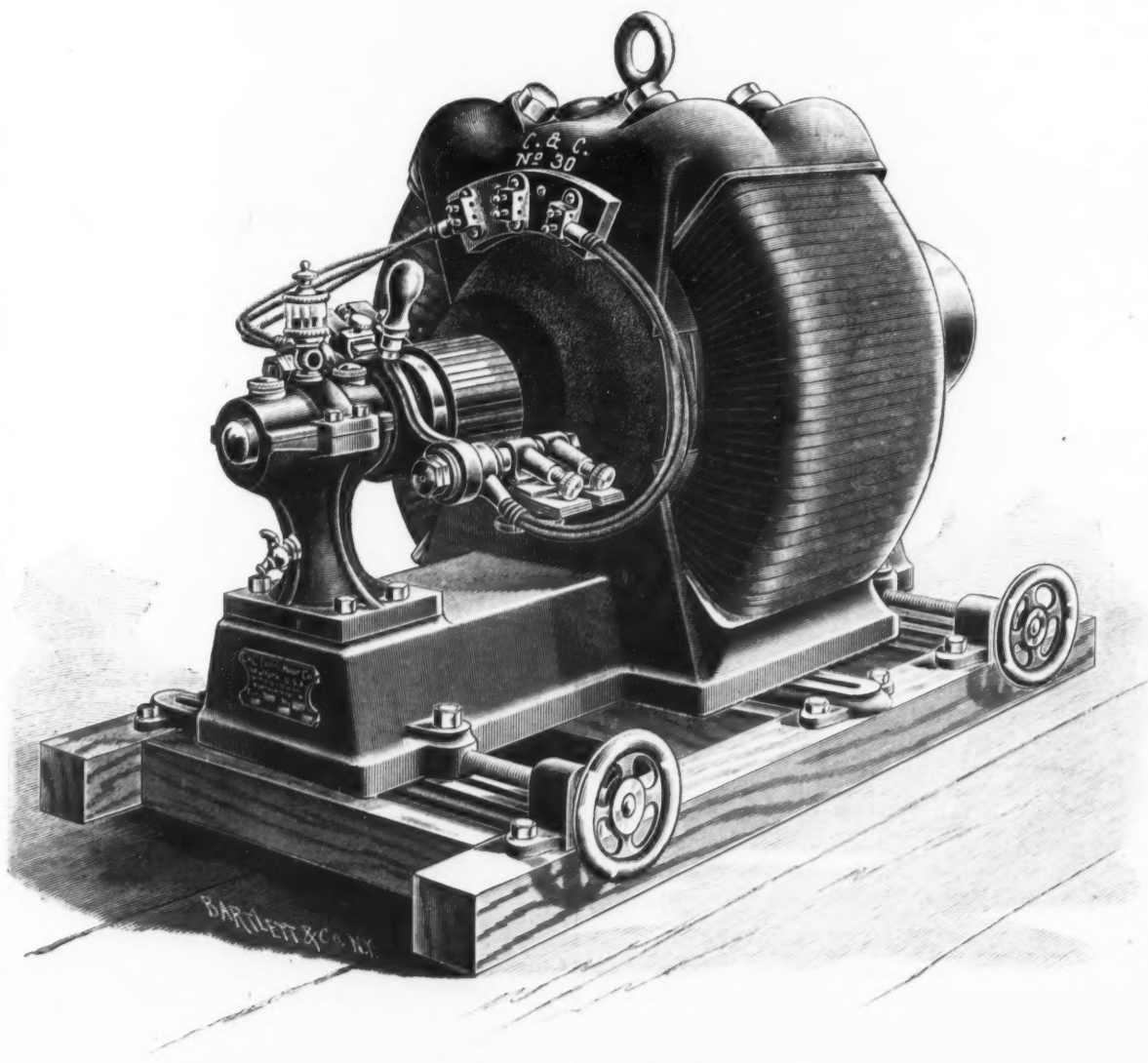


FIG. 1.—NEW C. & C. MOTOR.

that the engine will be a triple expansion condensing engine, using steam at 160 pounds pressure, and that a horse-power is guaranteed on 12.6 pounds of water. These figures are beautiful to look at; but let us investigate the matter further.

We are not told of any of the difficulties of this high steam, how the temperature being about 370 degrees, fewer pounds of water will be evaporated per pound of coal, and greater loss by condensation will occur than with a lower pressure and temperature. Nothing is said about the necessarily great difference in temperature of feed water as compared with the high temperature of the boiler, and the consequent still further loss of boiler duty per pound of coal. Both of these items, if overlooked, will lead us into serious error in comparing the figures given with those made under ordinary conditions. Another item must not be forgotten. Part of the work of this engine is expended on driving the air pump, and therefore the cost in water consumption of a *net* horse power available for making lights must be increased by just the ratio that this air pump work bears to the whole work of the engine, which will be found to increase very materially the actual water required per available horse power per hour.

Starting with the 12.6 pounds of water per horse power per hour, if we correct the figures for the three items mentioned, we shall have an amount considerably above 12.6 pounds but yet low enough to be a matter of great interest to steam users.

The great gain by high pressure and compounding, or triple expansion, is enough to attract attention when stripped of everything that might deceive.

As a matter of scientific experiment, it is interesting to obtain the highest possible duty from a pound of coal without regard to the complication or cost of the apparatus, but this last foot-pound of work from a given quantity of coal may have no commercial value.

Let me illustrate. Suppose an electric light station requiring two hundred horse power is to be equipped. I happen to know of just such a case, and one where a Reynolds-Corliss compound condensing engine was being considered. The builder's estimate for this engine was $6,000. Its guaranteed efficiency was a little above 15 pounds of water.

Another proposition was made to furnish two high speed compound condensing engines, guaranteed to develop power on 18 pounds of water per horse power per hour under the same conditions. These engines were offered at $1,500 each, or a total of $3,000 for 200 horse power, as against $6,000 for the Corliss engines. Add to this $6,000 the cost of main driving belt, line shafting, friction clutch, pulleys, pillow blocks, and foundations for the same, and we have the Corliss engine ready to belt to dynamos, at a cost of about $7,000 as against $3,000 for the two high speed compounds, assuming the erecting, &c., to be left out as costing the same in either case.

The practical question which confronted the projectors of this lighting station was, What dividends will be earned on the $4,000 additional cost by a saving of 3 pounds of water or one-third pound of coal per horse power per hour. The high speed compounds were chosen, perhaps, because they were "proven to be the best type of engines made." In comparing the engines in this case, the price of coal would be an important item, and also the number of hours of work done in a year. Other conditions might have important bearing also. For instance, if during any considerable portion of each day or night, the load was light, it might be that the single 200 h. p. Corliss engine would be very much more wasteful than one of the smaller engines, having a more suitable load, and the Corliss engine would also be under the disadvantage of always having the friction of the line shafting to contend

with. Thus the saving, when the engine is properly loaded, might be entirely wiped out by unfavorable conditions of light load as described.

The cost of repairs would certainly be against the Corliss engine, if it was charged with all repairs of clutch pulleys and line shafting and main driving belt.

Another and a very important consideration is the question of uncertainty always attending the use of a single engine, where everything stops if the engine stops. Sooner or later repairs must be made which cannot be done in a single day. What then is to be done? With the divided power, a third engine could be added as a reserve, entirely removing the question of uncertainty and still keeping materially inside of the cost of the single engine.

The interest manifested at this time in compound engines of all types, would indicate that they will be very largely used hereafter. It may fairly be said that the compound craze is on. Comparatively little is known of high speed compounds, but the indications are for a very bright future. Happening just now to be engaged in a series of tests of this type of engines, using a Wheeler surface condenser, and an outfit of apparatus and instruments that precludes the possibility of any appreciable error, I am prepared to fully confirm the figures of efficiency mentioned in connection with the 100 horse power compound, without any hesitation, and it therefore becomes merely a question of veracity.

The King Bell.

The accompanying illustrations, Figs. 1 and 2, represent the new "King" bell recently brought out by Messrs. Partrick & Carter, of Philadelphia. As will be seen, the working parts are all protected, so that they cannot become injured or deranged, being covered entirely by the nickel plated gong. The bell is neatly and substantially made and is built in one size with 3-inch gong.

Electric Tanning.

The process of electrical tanning (Worms and Balé's English patent, No. 9,515, 1887) appears to have been carried on for some six months at full work in France by the Société Française de Tannage, who turn out leather of the best quality. Some special harness for the Paris exhibition is to be made of leather so treated. The process consists of subjecting the hides in contact with ordinary tanning materials, without acids, to the action of a current of electricity in a revolving drum. The saving in time is very great—two to four days instead of three to nine months—while the cost is reduced to 1½d. or 2d. instead of 4d. A company under the name of the British Tanning Company (Limited), has been formed to work the process in England, of which several prominent tanners and Mr. William Crookes, F. R. S., are directors. The process, as carried on in France, has been favorably reported on by practical leather tanners and by Prof. Sylvanus Thompson, who found the electrical arrangement well conceived and carried out in a practical manner.

Sulphate of Soda in Storage Batteries.

To the Editor of The Electrical World:

SIR: In the editorial on storage battery management in your valuable issue of May 25, you state in reference to the prevention of formation of sulphate in the battery, by adding sulphate of soda to the usual sulphuric acid solution, that you are not aware that this practice is followed to any extent in this country, or even advised by the makers of storage batteries here.

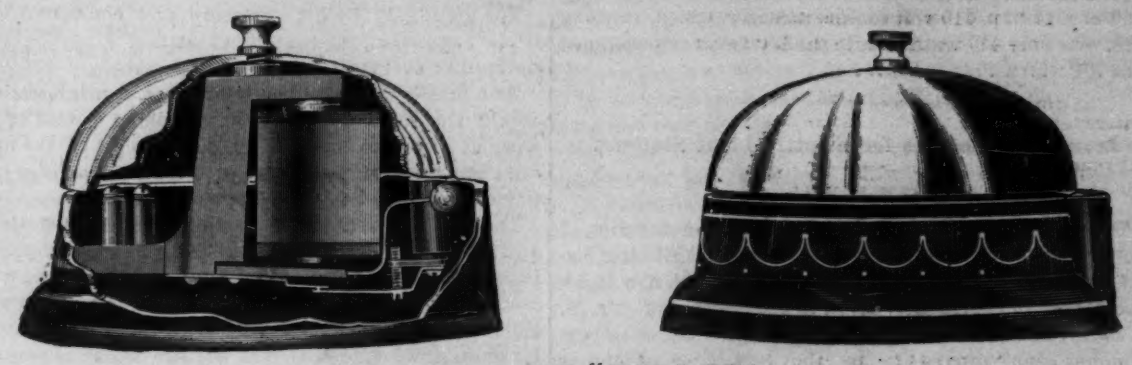
We would acquaint you that several of our clients have installations of storage batteries in this country in which sulphate of soda forms a considerable percentage of the active ingredients of the electrolyte. This addition, brought about by the introduction of carbonate of soda into the cell during action, has been known on the other side for some years prior to the date of Mr. Preece's paper. Similar results can be obtained with magnesia salts; and in fact, it is only the ignorant in the art who may be said to be in any way trammeled with the formation of sulphate in a properly constructed storage battery cell.

NEW YORK, May 23. PAGET AND KINTNER.

The Ganz Alternate Current Motor.

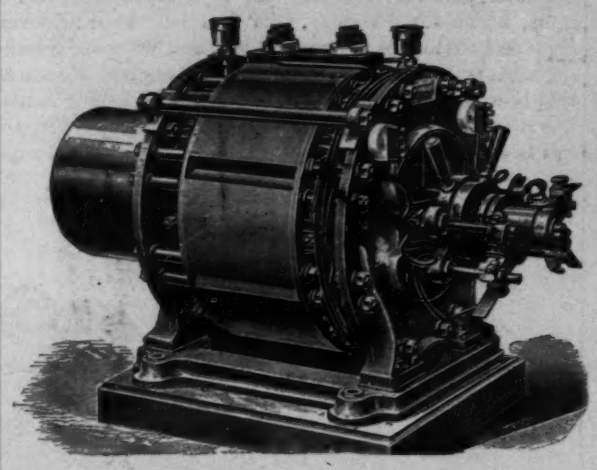
In our issue of May 4 we gave some account of the new alternate current motor of Messrs. Ganz & Co., of Budapest, and we are enabled this week to present an illustration of the machine, taken from *Industries*. Owing to the necessity of guarding patent rights no detailed description of the machine has been furnished, but it will be seen that in general design and appearance the motor resembles the alternate current dynamo of the same firm.

It is interesting to note that motors of this type are already being installed in connection with some central



FIGS. 1 AND 2.—THE "KING" BELL.

stations which Messrs. Ganz & Co. have in hand. One of these stations is now in course of erection at the paper works, of Wattens (near Innsbruck), where a turbine of 60 h. p. will be used to drive an alternator producing a current of 500 volts, which will be conveyed by an



GANZ ALTERNATING CURRENT MOTOR.

overhead circuit to the paper mill, about two-thirds of a mile distant. The current will be utilized at this mill for operating an alternate current motor of 50 h. p. In another installation, viz., at Wiener-Neustadt, a waterfall of 80 h. p. will be utilized for driving a 50 kilowatt Ganz alternator, giving 2,000 volts at 25 ampères, the current being used for lighting the railway station with 200 glow lamps, and for supplying power to a brewery in the neighborhood. For this purpose there are being installed two alternate current motors of 10 h. p. and one of 5 h. p. The 10 h. p. motors are speeded at 820 revolutions, and the 5. h. p. motor is speeded at 1,250 revolutions. The distance between the generator and motors is 1¼ miles. This installation is due to the initiative of Herr Max v. Bernd, and is claimed to be the first example of the use of alternating currents for lighting and power purposes jointly from the same central station.

The Telephone in Spain.

From recent statistics it is shown that 30 towns in Spain possess telephone systems, with a total of 4,585 subscribers, the tariffs ranging from 85 to 300 pesetas—say $15 to $55—per year. Curiously enough, out of all these concessions 28 are held by private individuals, and only two by telephone companies. These are at Madrid, where the Sociedad General de Telefonos has 1,456 subscribers, and at Barcelona, where the Sociedad Española de Electricidad has 774. The remaining private enterprises range from 438 (at Bilbao) downwards. Madrid telephones have paid 10 per cent. for 1888.

The Electrical Gyrostat.

To the Editor of The Electrical World:

SIR: Will you kindly allow me to make a slight addition, as I am afraid my former communication may have been liable to misconstruction. It was not intended to suggest that a gyrostat once pointed north would continue to do so indefinitely. In practice it would probably vary. Some means must be taken to prevent it from doing so, and the following suggests itself:

The rotation plane of a gyrostat makes a fixed angle with a plane in space. Therefore its axis, if placed horizontal in any direction except north and south, will soon form a perceptible angle with the horizon. If any simple device be attached, such that when the north-seeking end of the axis rises above the horizon it will be pushed to the left, and vice versa, the axis must always lie due north and south. Its error will depend on the delicacy of the instrument.

I regret that time does not permit of my making the experiment, as it might prove of interest.

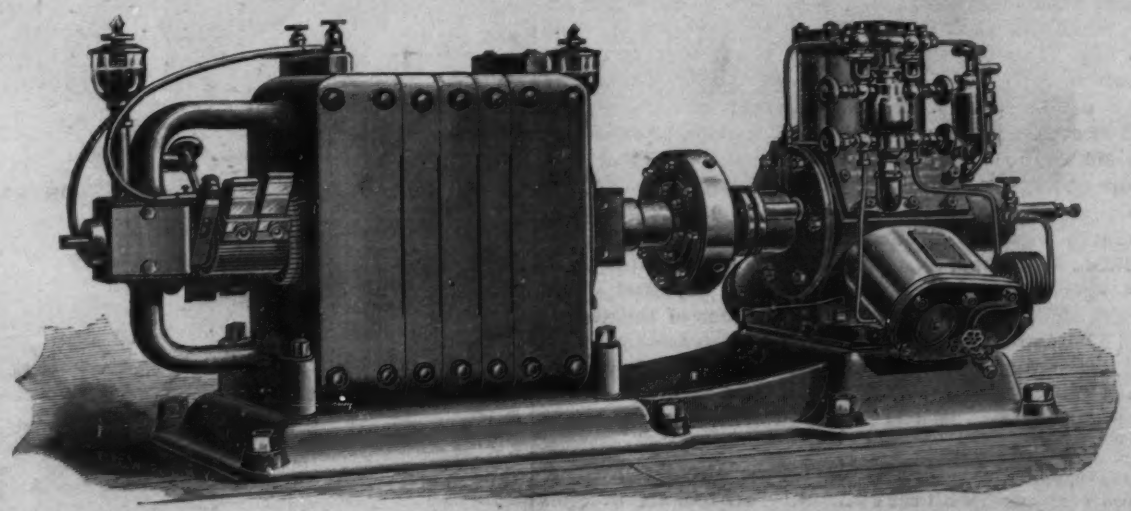
REGINALD A. FESSENDEN.

EDISON LABORATORY, ORANGE, N. J.

Combined Eickemeyer Dynamo and Brotherhood Engine.

When the project of lighting trains electrically by the aid of storage batteries was first broached it was considered that the charging at terminal stations would be all-sufficient to maintain the batteries in proper condition to do their required work. While this plan is quite feasible where short distances only are run, it is evident that where the batteries are required to deliver current for a somewhat extended period of time, the weight of batteries necessary to furnish the required ampère-hour capacity might become such as to make this plan impracticable. An easy way out of the difficulty, therefore, is to have a limited number of cells which are kept charged by means of a dynamo and auxiliary engine on the train. This plan has been adopted on a number of lines in this country, among others on that of the Pennsylvania Railroad Company, for their limited Chicago and New York trains, and on the Chicago, Milwaukee & St. Paul Railroad. Naturally such a plant is required to occupy as small a space as possible, and to that end special arrangements must be made. The Pullman Palace Car Company, which has equipped most of its cars with electric plant, has given considerable attention to this subject and has adopted the Eickemeyer "ironclad" dynamo directly connected with the three-cylinder Brotherhood engine as its standard generating plant.

Our illustration shows the dynamo and engine combined. As usually installed, the dynamo has a capacity



THE COMBINED EICKEMEYER DYNAMO AND BROTHERHOOD ENGINE.

of 80 ampères at 80 volts. The engine is capable of delivering 21 h. p. at 1,600 revolutions, and the exhaust is used for heating the cars when necessary. The little plant, which occupies a corner of the baggage room, 6 feet 3 inches by 3 feet 3 inches, is provided with all the necessary instruments for ascertaining the condition of running, being provided with a voltmeter, ammeter, tachometer and a number of switches, among which is an automatic switch for preventing the current from the battery passing into the dynamo, and reversing the machine.

Each car is provided with 32 cells of the 23 C type of the Electrical Accumulator Company. Each sleeper has 26 lamps, and the smoker and dining car each 21 lamps. In addition, each section is provided with a socket, connected with the leads, for the insertion of a plug, and a lamp with a flexible cord for the use of invalids. The push-buttons for summoning the porters are also operated by the storage batteries, for which purpose two cells are

UNIVERSITY OF CALIFORNIA

tapped. The arrangements of the entire plant and equipment have been in charge of Mr. A. H. Bauer, the Pullman Company's electrician, and are exceedingly well worked out. The Eickemeyer dynamos have been furnished by J. H. Bunnell & Co., of this city.

Electric Motor Regulation.*

BY FRANCIS B. CROCKER.

Although this subject is one of great scientific and practical interest, it has not been very frequently or very fully treated up to the present time. Of course, motor regulation is very similar to dynamo regulation, but it is by no means identical with it, and it deserves and requires separate treatment. I do not think it is much exaggeration to say that at the present time there is no subject more generally important to electrical engineers than motor regulation. Considering this fact, it is certainly remarkable that the literature of the subject is so limited. We find stray articles in electrical periodicals, rarely more than a description of one particular invention, and in electrical books, regulation is referred to incidentally in connection with descriptions of the various motors. There is also, to be sure, usually one short chapter devoted to this subject, but it is apt to be either very general, merely mentioning a few regulating devices, or else it is confined to the mathematical analysis of some one particular method.

Motor regulation is a subject which is somewhat confusing, and requires therefore accurate definition of the quantities and conditions which enter into it. One case is, at first sight, very similar to another, and yet, more careful consideration will show, very likely, that it is exactly opposite. Take for example the two commonest and most important cases, viz., the constant potential and the constant current motors. The conditions of the two cases are precisely opposite, and the solution of the problem is, naturally, entirely different. To maintain a motor at a constant speed with a variable load, on a constant potential circuit, which is the case of the ordinary shunt motor on the regular 110 volt incandescent circuit, is a very easy problem—in fact, it solves itself. A simple shunt-wound motor will run at a practically constant speed on a constant potential circuit, even if the load varies from zero up to the full capacity of the motor. Now this form of motor is exactly what we would use, even if we did not care to have it regulate. It is customary, to be sure, where very close regulation is required, to wind constant potential motors differentially, *i. e.*, with series as well as shunt coils, but this is not essential for ordinary work.

The case of the constant current motor, on the other hand, is as difficult as the first is easy. It seems as if it had to bear the burden of both. Neither a shunt-wound nor a series-wound nor a compound-wound motor can be used practically on a constant current circuit to maintain a constant speed with variable load. The ordinary series-wound motor, which is the natural and common form for the constant current motor, will race away when the load is taken off and increase in speed until it tears apart or strains the armature and ruins the machine. We require some special and very effective device to accomplish the regulation in this constant current case, and it seems to happen that almost every device that has been thought of has serious difficulties and complications. The ordinary, and what would seem to be the best, solution of this problem is to vary the magnetic effect of the field upon the armature directly in proportion to variations in the load. This is effected by cutting out the field coils, and by other methods which will be described later. But there are difficulties with almost all these plans.

These two cases, which, as already stated, are the commonest and most important which occur, and yet which are so very different in almost every respect, give a general idea of what we have to deal with in motor regulation.

In order to fix and hold the rather numerous quantities and conditions that present themselves in connection with motor regulation a tabular statement of them is given below:

TABLE I.

ELECTRIC MOTOR REGULATION.

1. Hand regulation.
   Usually employed for varying the speed.
2. Automatic regulation.
   Usually employed to maintain constant speed, and is effected by
   - Centrifugal governors.
   - Dynamometric governors.
   - Electro-magnetic devices.

PRINCIPAL METHODS OF MOTOR REGULATION.

1. Shunt winding. Fig. 1.
2. Differential winding. Fig. 2.
   Varying external resistance in series with
3. Armature.
4. Field. Fig. 1.
5. Both armature and field.
   Varying internal resistance of
6. Armature.
7. Field by cutting out coils in series. Fig. 3.
8. Field by cutting out coils in multiple arc. Fig. 4.
9. Field by grouping coils in series or multiple arc.
10. Both armature and field. Fig. 5.
    Varying shunt in multiple arc with
11. Armature.
12. Field.
13. Both armature and field. Fig. 6.
14. Varying current in separately excited field.
15. Shunting field magnetism. Fig. 7.
16. Short circuiting field magnetism. Fig. 8.
    Varying commutation by
17. Shifting brushes. Fig. 9.
18. Shifting commutator.
19. Shifting magnetic resultant.
20. Moving pole-pieces away from armature. Fig. 10.
21. Moving armature away from pole-pieces. Fig. 11.

TABLE II.

LIST OF POSSIBLE CASES WITH DIRECT CURRENTS.

P = Difference of potential in volts at terminals of motor.
C = Current in ampères supplied to motor.
S = Speed of armature in revolutions per minute.
L = Load or torque in lbs. at one foot radius.

Any of these four quantities may be either constant or variable, making the following combinations:

Case.	Constant.	Variable.	Example.
1.	P	CSL	Series wound motor with variable load on const. pot. cir.
2.	PS	CL	Shunt or comp. wound motor with variable load on con. pot. cir.
3.	PL	CS	Shunt motor with con. load and var. field resist. on con. pot. cir.
4.	PSL	C	Not practical.
5.	PC	SL	Not likely to occur.
6.	PCS	L	Impossible.
7.	PCL	S	Impossible.
8.	$PCSL$		Shunt motor with contant load on constant potential circuit.
9.	C	PSL	Shunt motor with var. load on constant current circuit.
10.	CS	PL	Series motor with speed gov. and var. load on const. cur. circuit.
11.	CL	PS	Series on arc const. torque.
12.	CSL	P	Not practical.
13.	S	PCL	Motor with speed gov. and var. load on cir. of var. pot. and cur.
14.	SL	PC	Motor with const. load and speed gov. on cir. of var. pot. and cur.
15.	L	PCS	Mot'r with c.n. load without speed gov. on cir. of var. pot. and cur.
16.		$PCSL$	Mot'r with var. load without speed gov. on cir. of var. pot. and cur.

In Table I, motor regulation is divided into hand regulation which, it happens, is almost always used for varying the speed of a motor, by a hand switch Fig. 1, for example, and automatic regulation, which is almost always used to maintain a constant speed, and which is usually accomplished in one of the three following ways: First, by a centrifugal governor similar to that of the steam engine, operating a switch or other device, Fig. 3.; secondly, by a dynamometric governor, i.e., a mechanism through which the load or torque of the motor is transmitted, which may also operate a switch and vary the power of the field by the direct effect of changes in the load; thirdly, by an electro-magnetic device, such as a solenoid, through which the current, or a portion of it, is passed which causes the core of the solenoid to move and operate a switch in accordance with variations in the current, Fig. 9.

The table next gives the principal methods used to regulate motors. These consist of different arrangements and combinations of parts to produce different effects or changes in the working of the motor, and they constitute the means which we have to employ to accomplish a certain object in motor regulation. Method 1. is simple shunt winding, which consists in exciting the field magnet with a circuit of comparatively high resistance in multiple arc with the armature (Fig. 1). This maintains a motor at constant speed with varying load on a constant potential circuit, and does this all by itself, as it were, without any trouble, as already pointed out. The reason for this is that the field, being fed with a constant potential, is therefore, of constant strength, and a slight variation in speed of the armature, about 5 per cent., will vary the current in it from zero up to its full capacity, and therefore vary its power to an equal extent.

Method 2 is differential winding (Fig. 2), which is a refinement of the first, by which an almost absolutely constant speed, *i. e.*, within one or two per cent., may be practically maintained. This consists in winding a series coil of comparatively few turns upon the field magnets, in addition to the shunt-winding in the previous case, the series coil being wound in the opposite direction and opposed magnetically to the shunt coil. The effect of this is to slightly weaken the field magnetism as the load on the armature, and consequently its current, increases. This tends to increase the speed of the armature and counteract its tendency to slow down with increased load, thereby almost entirely eliminating even the small variation of 5 per cent in speed which occurs in the ordinary shunt motor. The paradoxical fact that a shunt motor increases its speed with the weakening of the field magnet is well known, being due to the lowering of the counter electromotive force, and consequent increase of current in the armature as the field magnetism is reduced in intensity.

In the next three methods the external resistance in series with the armature or field, or both, is varied. Method 3 would be very wasteful, and is hardly allowable in good practice, because it is simply destroying the main current to put resistance in the armature circuit. Method 4, varying the resistance in the field circuit is very much less objectionable, and is very convenient and common (Fig. 3). This mode can be adopted with a very small loss of current, because the field current is only a small part of the total current used in the motor, and the loss of a portion of this small fraction is practically insignificant. Method 5, putting external resistance in series with both the armature and field is open to same objection as Case 3, since it throttles and destroys part of the main current.

The next five modes of regulation, 6, 7, 8, 9 and 10 are theoretically more economical than the preceding, because we vary the internal or useful resistance instead of adding external or dead resistance. Method 6, in which the internal resistance of the armature is varied, is very difficult to carry out in practice, simply because it is hard to get at and change the connections of the armature while it is revolving. One of the few ways devised to accomplish this is to wind the armature with two or more circuits connected to a corresponding number of commutators, whereby one or more of these circuits may be used, thus varying the internal resistance and torque. This is clumsy, and practically little better than using two or more separate motors.

Method 7, cutting out the field coils in series is a very simple and

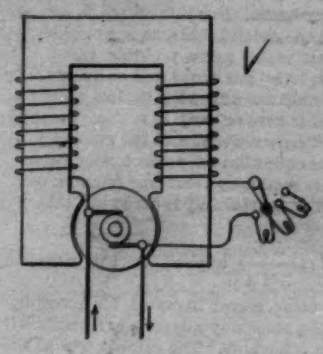


FIG. 1.—Shunt Motor with Variable Resistance in Field Circuit.

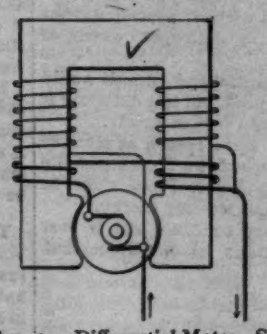


FIG. 2.—Differential Motor. Self-Regulating.

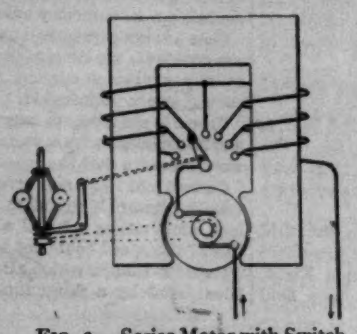


FIG. 3.—Series Motor with Switch for Cutting Out Coils in Series.

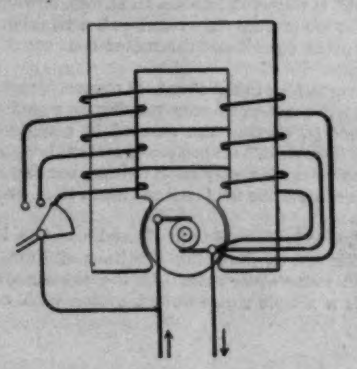


FIG. 4.—Shunt Motor with Switch for Cutting out Field Coils in Multiple Arc.

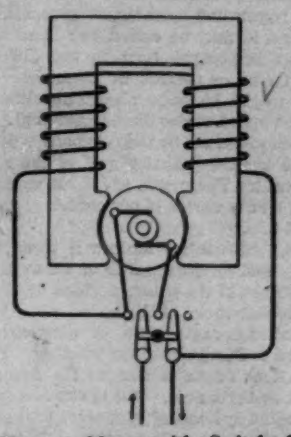


FIG. 5.—Motor with Switch for Throwing Armature and Field in Series or in Multiple Arc.

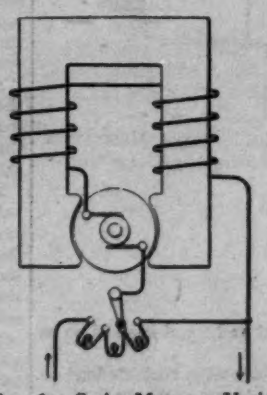


FIG. 6.—Series Motor on Variable Shunt.

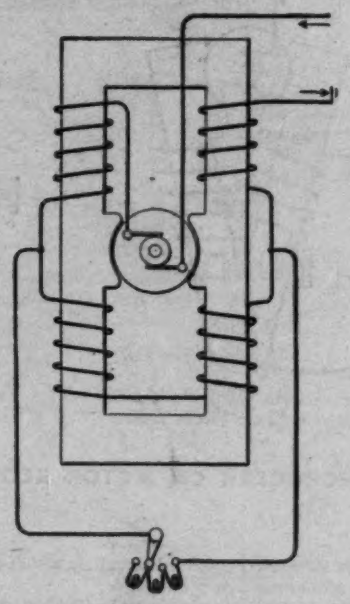


FIG. 7.—Series Motor with Variable Magnetic Shunt.

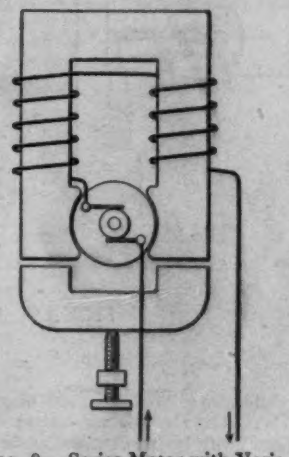


FIG. 8.—Series Motor with Variable Magnetic Short Circuit.

FIGS. 1, 2, 3, 4, 5, 6, 7 AND 8.—CROCKER ON MOTOR REGULATION.

* A paper read before the American Institute of Electrical Engineers, New York, May 22, 1889.

common plan. It is the ordinary way of regulating constant current or other series-wound motors. This method, or some modification of it, is one according to which the constant current or "arc" motors of the Baxter, "C. & C." and Excelsior companies are constructed. Method 8, of cutting out field coils in multiple arc, is shown in Fig. 4, and is especially applicable to shunt-wound motors. The different layers, for example, may be respectively connected to the contact points of a switch and thrown into circuit successively, the innermost layer first, etc., thus obtaining the most economical result.

Method 9 of grouping the field coils in series or multiple arc, produces very great variations in field resistance and is a combination of the two preceding cases. Like them it consists in winding the field with separate circuits which are connected to a switch. This is employed in street car motors to obtain the great variations in resistance and power required of them.

Method 10 is also merely a combination of two or more of the four preceding cases. A simple way of carrying it out is illustrated in Fig 5, and consists in connecting the armature and field either in series or in multiple arc, by which a great variation in the total internal resistance of the machine is obtained.

The next method, No. 11, is open to the same objection as No. 6, because when the armature is shunted the main current of the machine is affected. This is, however, less objectionable than dead resistance, because in most cases it is better to divert the current than to destroy it.

Method 12, like methods 4 and 7, is a useful and common one, because in shunting the field we are merely handling a very small fraction of the total current.

Method 13, varying a shunt in multiple arc with both armature and field, is wasteful, like No. 11. It was, however, the plan by which the first arc motors were regulated, a variable shunt being placed in the main circuit and the motor connected to the terminals of the shunt.

The variations in the shunt, of course, throw more or less current through the motor, thereby varying its power as required.

Method 14, varying the current in a separately excited field, is merely historical, as this class of motors has gone out of use. The plan, however, is a very effective one, because, of course, it is very easy to control the field current when it is produced by a separate source.

Method 15 is shown in Fig. 7, and consists in shunting the field magnetism, *i. e.*, diverting the lines of force from the armature through some other path. In the arrangement shown in Fig. 7, there is a simple series-wound motor with consequent pole field

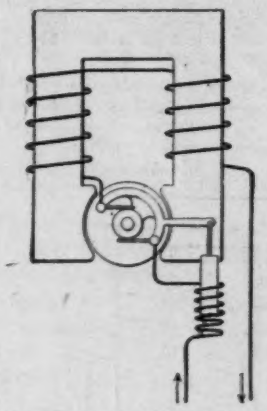


FIG. 9.—Series Motor with Automatic Device for Shifting Brushes.

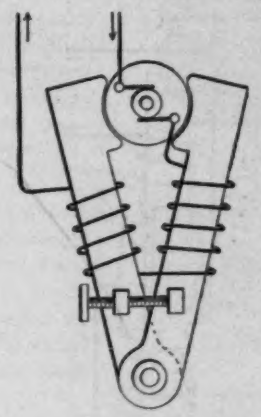


FIG. 10.—Series Motor with Device for Moving Pole Pieces Apart.

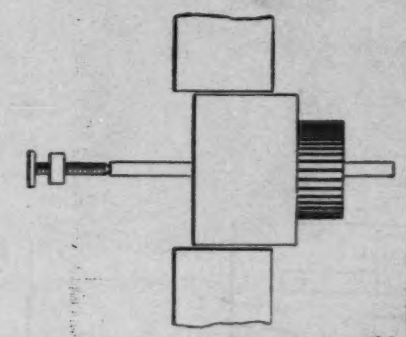


FIG. 11.—Series or Shunt Motor with Regulator for Moving Armature Out of Field.

FIGS. 9, 10 AND 11.—CROCKER ON MOTOR REGULATION.

magnet, and if the coils exciting one magnetic circuit are short-circuited, it is evident that the magnetism produced in the other magnetic circuit will be short-circuited or shunted by the former. The short-circuiting of the coils is effected by the variable shunt, as indicated.

Method 16 is very similar to the preceding, and consists in short circuiting the field magnetism and diverting it from the armature by a keeper, which may be moved towards or away from the pole pieces by means of a screw or other contrivance.

We now come to methods 17, 18 and 19, in which the line of commutation is varied. The first is the well known plan of shifting the brushes. This is very effective and easily carried out, and has, therefore, been used quite extensively, but it has the very serious and almost prohibitory objection that when the brushes are moved from the neutral point they spark very badly. This may be remedied to a slight extent by some heroic plan like blowing out the spark produced. But, as sparking is one of the worst drawbacks of a motor, it hardly seems as if this method of regulation would be permanent.

Methods of regulation which are all right for dynamos may not be allowable in the case of motors, because the former is usually in the hands of skilled men devoted to their care, while motors are often run by ignorant and careless persons.

Method 18, shifting the commutator, is simply another way of doing the same thing as shifting the brushes.

Method 19, shifting the magnetic resultant or direction of lines of force in the armature, may be accomplished by two sets of pole pieces, the relative magnetic strength of which is varied. This is also open to the same objection as shifting the brushes.

Method 20, shown in Fig. 10, consisting in moving or separating the pole pieces from the armature, has been used in the Diehl and other motors, but it is rather difficult to carry out mechanically, and introduces a hinge or joint in the magnetic circuit, which is, of course, very undesirable.

Method 21, moving the armature away from the pole pieces, is very much easier to accomplish mechanically, and has a great many advantages as a means of regulation. Mr. S. S. Wheeler and myself have been working for some time on motors in which this method of regulation is employed, and the results we have obtained have been very satisfactory; in fact, we have found it to be extremely simple, effective and reliable.

The second table gives a list of the possible cases of motor regulation which may occur with direct or continuous currents. There are four supremely important quantities or conditions in connection with electric motor regulation, viz., potential, current, speed and load, and it is with reference to one or more of these that practically all motors are designed, built, sold and used. Motors are always distinguished, both in science and in trade, as constant potential or constant current motors; constant or variable speed motors, and constant variable load motors; hence a classification of motors based upon the constancy or variability of these four factors is very convenient, and at the same time scientifically correct. The second table is made upon this plan, and in it the four quantities are represented by their initial letters P, C, S and L, expressed respectively in volts, ampères, revolutions per minute and torque in pounds at one foot radius, these being the units ordinarily used in practical as well as scientific work. We find that there are in all sixteen different cases, in the first four of which the potential is constant; in the second four the potential and current are both constant; in the third four the current only is constant, and in the fourth four neither the current nor the potential is constant.

Case 1, in which the potential alone is constant, is the case of a series-wound motor, for example, with variable load on a constant potential circuit. Such a motor would rise in speed when the load was reduced, and vice versa. It would not be at all self regulating —in fact, it would tend to run at a very high speed with light load, and a very low speed with a heavy load. It is possible to give various other examples, but one is sufficient in most cases. In this case, however, I may say that the ordinary street car motor, fed from a constant potential circuit, is also an example of Case 1, the current being controlled by varying the external or internal resistance, according to one of the methods given in the first table.

Case 2 is that of the ordinary shunt or differential motor, with a variable load on a constant potential circuit. This is self regulating and maintains its constant speed, as already stated, and is the commonest case of motor regulation met with. The current varies directly with the load.

Case 3 is that of the ordinary shunt motor with constant load, having a variable resistance in the field magnet. This case is shown in Fig. 1. Increasing resistance of field circuit would weaken the field magnetism and the motor would run faster and take more current; *i. e.*, current would vary directly with speed.

Case 4 is not a practical one, because, if potential, speed and load are constant, the current cannot be varied without wasting it; that is, any excess of current would be simply destroyed, which, of course, is not permissible.

Case 5 is not likely to occur, because potential and current would not be constant with a variable load and speed, but if it did occur it would require that the speed and load should vary inversely.

Cases 6 and 7 are not practical for the same reason as given in Case 4, because if potential, current and speed were constant the load could not be reduced without wasting electrical energy, and in Case 7 the speed could not be varied without wasting energy.

Case 8 is that in which all four factors are constant, and is best illustrated by a shunt motor with constant load on a constant potential circuit, in which case the current and speed would also be constant.

Case 9 may be illustrated by a shunt motor with variable load on a constant current circuit. The speed would run up as the load reduced. A more common example is a series motor on constant current circuit, with switch for cutting out field coils, or, in short, a constant current motor with variable speed and load.

Case 10 is that of the regular constant current or "arc" motor with governor, such, for example, as the Baxter or "C. & C.;" it is a series motor with a centrifugal governor which operates a switch to cut in and out the field coils as shown in Fig. 3. This is, next to the shunt and differential wound motors, the most common and important case of motor regulation.

Case 11 is that of a constant current motor with constant load, with switch for varying field strength. The potential would rise directly with speed, but this case is not likely to occur.

Case 12 is not practical for the same reason as given in case 4.

The last four cases are those in which both potential and current vary. They are hardly practical cases, because electrical distribution is almost always either at constant current or constant potential. It is, however, of course, possible to have cases where both may vary, and examples of each case are given.

Case 13 is one which does occur to a certain extent in practice; for example, if a so-called constant current circuit varies slightly, as it always does in practice, say from 9 to 10 ampères, then the current as well as potential is variable to that extent, and this must be taken account of in the regulation.

In the experiments which I have already referred to, Mr. Wheeler and I have built a motor of the constant current type which will govern for wide variations in current as well as in load. This motor, for example, will not fall in speed, even though the current be reduced from 10 to 5 ampères, which is a great variation for this type of motor, as the field and armature, being in series, the torque varies as the square of the current. This variation in current in the so-called constant current circuits is a much greater percentage than the variation in potential of so-called constant potential circuits, and amounts to ½ to 1 ampère.

Having generally described the different cases of motor regulation, let us take up the mathematical relations of potential, current, speed and load, which may be expressed quite simply.

Using the symbols P C S and L as defined above, we have $P \times C$ as the total electrical energy supplied to motor in watts, or $\frac{P\,C}{746}$ in horse-power. Calling commercial efficiency a the actual mechanical horse-power developed by a motor is $\frac{a\,P\,C}{746}$ expressed in electrical terms. The equivalent expression in mechanical terms is $\frac{2\,\pi\,S\,L}{33000}$. Since the point at which load L is measured is 1 ft. from centre of shaft and travels $2\,\pi$ feet per revolution, or $2\,\pi\,S$ feet per minute. This, multiplied by the load and divided by 33000, ves the horse-power developed by the motor.

Thus we have:

$$\frac{a\,P\,C}{746} = \frac{2\,\pi\,S\,L}{33000} = \text{h. p. of motor}$$

or

$$P\,C = \frac{746 \times 2\,\pi\,S\,L}{33000 \times a} = \frac{S\,L}{7.04 \times a}$$

For convenience we may write $P\,C = \frac{S\,L}{7a}$ with an error of about one half of one per cent.

If the efficiency a of motor is 85.2 per cent. the denominator, or $6a$ becomes 6 exactly, and we have $P\,C = \frac{S\,L}{6}$; and if the efficiency is 75.8 per cent. we have $P\,C = \frac{S\,L}{5}$. The former is as high and the latter is as low as is ordinarily met with in practical work; therefore, these are the limiting values.

The equation $P\,C = \frac{S\,L}{7.04\,a}$, or one of the three simplified forms just given, may be advantageously used for solving problems n motor regulation. If we know any four of the quantities we may, of course, find the fifth by simply solving the equation with respect to it. It is also evident that if any three of the quantities are constant then the other two will vary directly or inversely with each other, depending upon their position in the equation. This is the ordinary case we have to deal with in regulation. Usually speed is required to be constant, either potential or current is maintained constant, and efficiency should be practically constant down to very small loads; thus we have either current or potential or load varying directly with load. The efficiency is rather a confusing element in motor regulation. For this reason it was not introduced as a fifth quantity in the second table, as it would have complicated it and made a great many more possible cases. The efficiency should be high (close to 100 per cent.) and as nearly as possible constant, therefore it would not affect the figures much.

If the load or speed is zero or very low the potential or current should be correspondingly reduced and the efficiency would remain constant. This is the condition for perfect regulation. Practically it always takes some current to overcome friction, etc., even when load is zero, in which case efficiency is zero; but this current should be very small.

The equation $P\,C = \frac{S\,L}{7.04\,a}$ applied to the cases marked "not practical" in second table, shows in case 4, for example, that if $P\,C$ and L are constant, the efficiency a decreases directly with reduction in speed. This is not allowable. The same is true of the other cases and shows that it is not proper to vary $P\,C\,L$ simply at the expense of efficiency, or, in other words, waste current, to obtain regulation.

Having now given the general points of motor regulation, we will consider the forms of motors which are now being used extensively.

First and most important, we have the regular shunt motor for constant potential circuit, which has already been referred to several times. Thousands of this type of motor are in use, and give very satisfactory results. A properly designed motor of this kind will regulate within 5 per cent., which is near enough for most purposes. It has no regulating mechanism or complicated circuits to get out of order, and it may be called the ideal self regulating machine. The next important form is the differential-wound motor, which is even more perfect in closeness of regulation, theoretically, and it might be made almost absolutely constant in speed; practically the speed varies about 2 per cent.

These are the figures given me by the company who manufacture these machines in the largest quantity and of the most excellent workmanship. Sylvanus Thompson gives an example of one of these machines, which only varied ½ per cent. in speed, with a variation from 1.1 to 11.14 h. p.

The rule for winding differential motors is that the number of turns in the shunt divided by the number of turns in the series coil are equal to the resistance of the shunt divided by the resistance of the armature plus the resistance of the series coil. On this side of the Atlantic this is called Sprague's law of winding; on the other side it is called Ayrton & Perry's rule for winding. The slight variation in speed which does occur is due to the heating of the two coils and other slight disturbances. The shunt coil varies considerably in resistance effected by heating; therefore the series coil should have a few less turns than the rule requires. The heating of the shunt coil weakens the current in it, and consequently the field magnetism, thus increasing the speed of the machine, therefore the motor runs faster after it has been running for some time. The proper way is, of course, to consider the true speed to be that which the motor has in steady running. At first, some trouble was experienced in this type of machine on account of short-circuiting between the series and shunt coils, but this has been overcome by more perfect insulation.

The shunt or differentially-wound machines may be varied in speed by putting resistance in the field circuits, as shown in Fig. 1. This may, of course, be done automatically, or by hand, usually the latter.

The next important type of machine is the constant current motor. As already stated, this is merely a series-wound machine, with switch for cutting in and out the field-coils, the latter being operated by an automatic centrifugal governor, as indicated in Fig. 3, or by hand. Various modifications of this type have been made—for example, a reversed coil may be wound on the field magnet coil and having a variable resistance in circuit with it. If this resistance is very high the reversed coil has little or no effect. If this resistance is made very low it will rob the main coil of its current, and also neutralize its effect, thereby greatly reducing the strength of the field magnet. All these motors with varying field strength have the drawback that a certain time is required for the magnetism to vary, and the regulation is therefore sluggish. If we attempt to hasten this by laminating the field-core we have sparking at switch points, due to self-induction in field coils.

Constant current machines with regulator are now in great demand for arc circuits; in fact, it is not practical or safe to use a motor on an arc circuit without a regulator, as the danger of racing away is very great.

The differential winding of constant current motors to maintain constant speed is not practicable. The solution of it requires either that the efficiency should be very low, or that storage batteries be used in connection with the motor to maintain a constant difference of potential. Any such plan as this is, of course, very objectionable.

The three types just given are really about the only continuous current motors, used to any extent, in practice, and it seems that there is at present no demand for any other type.

Nothing has been said of the regulation of alternating current motors, because it is a radically different subject, and, moreover, alternating current motors tend to run synchronously, maintaining a constant speed and regulating themselves.

In conclusion, I would say that I would like to see this subject taken up by leaders in electrical science and given the attention which I think it deserves.

The Efficiency of the Arc Lamp.*

BY HATSUNE NAKANO.

Note.

The interesting results recently obtained by Mr. Merritt in the application of the method of Melloni to the investigation of the efficiency of the incandescent lamp have made it seem desirable to extend that method to the study of the arc lamp also.

Existing data concerning the efficiency of this source of light are exceedingly imperfect, being based chiefly upon measurements with the Bunsen photometer. Ordinary photometric determinations of the light-giving value of sources of illumination differing widely in temperature from the standard candle are necessarily at fault; and I have endeavored in a recent paper † to call attention

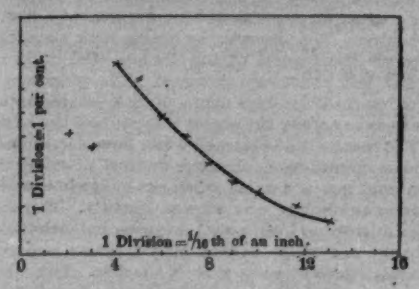


FIG. 1.—EFFICIENCY OF THE ARC LAMP.

anew to the character of the errors involved in the comparison of the light of the electric arc with that of other sources of artificial illumination.

The efficiency of the arc lamp has been expressed hitherto in terms of the candle-power of light produced per unit of energy expended. The estimate has been based in a few instances upon the mean spherical candle-power, as actually determined; more frequently upon the candle-power emanating from the lamp in a single, especially selected direction, and in too many instances upon the "nominal candle-power." Such estimates of the efficiency of the arc are of small value. They afford us widely varying results which cannot be definitely compared, and even when they are based upon the most complete and careful determinations of candle-power and energy, they do not indicate the ratio of light-giving radiation to the total energy expended within the lamp. It seemed, therefore, to be of some importance to obtain measurements of the ratio of luminous to total radiation in the case of the arc lamp by a method the results of which would be directly comparable with those already obtained for the incandescent lamp.

The investigation was undertaken, at my suggestion, by Mr. Hatsuné Nakano, M. E., of the Imperial University of Japan, the results of whose measurements are given in the following pages.

E. L. N.

ON THE EFFICIENCY OF THE ARC LAMP.

The following experiments were made in the Physical Laboratory of Cornell University during the winter of 1888-89, the object in view being to determine the efficiency of the arc lamp.

It is a well known fact that the comparison of the candle-power of differently colored lights, such as the candle and the electric arc, is only a rough approximation. By means of one of the methods recently described by Mr. Merritt,‡ however, we can determine the efficiency of the arc independently of its candle-power. The method in question enables us to find the ratio of the light-giving radiation to that of the total radiation of the lamp.

In his first experiments Mr. Merritt measured the heat given out by a lamp, which was immersed in the water contained in a calorimeter. It is evident that this method, though very ingenious, cannot be employed conveniently in the case of the arc lamp. His second method is, however, applicable to arc lamps as well as to incandescent lamps. This method and the arrangement of the apparatus were fully described by Mr. Merritt in his paper, read before the American Association for the Advancement of Science at their meeting in Cleveland. It was also described by Professor Nichols in his paper read before the American Institute of Electrical Engineers, March 12, 1889.

The application of the method to the arc lamp was as follows: The rays of the lamp were allowed to fall upon the face of a delicate thermopile which was in circuit with a sensitive galvanometer. The deflection of the galvanometer was taken as a measure of the energy of the total radiation which fell upon the face of the pile. § After the deflection due to the total radiation had been measured, a glass vessel of rectangular shape one decimeter thick, containing a strong solution of alum, was placed between the lamp and the thermopile, and the reduced deflection of the galvanometer observed. The use of the alum cell was to cut off the "dark heat," and allow only the rays of the visible spectrum to reach the face of the thermopile. But a certain small percentage of the longer wave-lengths passed through, and a considerably larger percentage of luminous rays were cut off by the cell. To determine the correction for the former source of error, a cell containing an opaque solution of metallic iodine in bisulphide of carbon was placed between the lamp and the alum cell. Any deflection now obtained was due to the dark rays passing through the alum cell, for the iodine cut off the luminous rays entirely, but allowed the dark rays to pass through. It was found that the dark rays which passed through the alum cell were exceedingly weak—almost imperceptible in most cases.

The correction for the second source of error, viz., the absorption of the luminous rays by the alum cell, was determined photometrically. The average of some thirty measurements gave 26 per cent. for the value of the correction.

In my first measurements, the lamp (the centre of the arc) and the thermopile were placed in the same horizontal plane. The lamp used was a "rack-feed" arc lamp requiring 45 volts and 9 ampères for its normal operation. Experiments were made with a dozen or more of different sizes of carbons, ranging from 2-16 up to about 13-16 inch in diameter.

The efficiency, or the ratio of the energy of the luminous radiation to that of the total radiation, luminous and non-luminous, in this plane was found to be exceedingly small, varying from about 5 per cent. to a little less than 15 per cent., the ratio increasing as the diameter of the carbons used decreased. This relation between the efficiency and the diameter of the carbons, which is shown graphically by means of the curve in Fig. 1, ceased to exist, however, when the point was reached at which the whole length of the carbons was rendered hot by the current passing through them. After this point was reached the efficiency fell off again.

Table I gives the results of these measurements. In the first column the diameters of the carbons (in thousandths of an inch) are given. The second column shows the "mean horizontal efficiency;" that is to say, the ratio of the deflection produced by the total radiation of the lamp to that due to the light-giving radiation alone, after the proper corrections for absorption and diathermancy have been applied. Each value is the mean of a series of observations. The third column gives the potential difference between the terminals of the lamp.

TABLE I.

Diameter of Carbons. (In inches.)	Horizontal efficiency.	P. D. (Volts.)
.832	.01484	42
.730	.02162	45
.605	.02527	43
.563	.03125	38
.500	.03893	38
.432	.05014	38
.370	.05861	28
.305	.07338	31
.250	.0813	56
.185	.0458	25
.124	.0514	30

The curve *C D*, given in Fig. 1, shows the relation between the efficiency, measured in the horizontal plane, and the diameters of the carbons. The ordinates represent efficiencies, and abscissæ the diameters. It will be noticed that the points *A* and *B*, corresponding to 2-16 and 3-16 inch carbons, are far below the curve, showing that the relation is modified as soon as the carbons become too small to carry the current without heating.

In the electric arc, as Prof. Nichols has shown in the paper already referred to, "the entire light-giving area is included between the line surrounding the positive carbon, which is at red heat, and the corresponding line upon the negative carbon. Now the surface of total radiation is much larger than that from which the light-giving rays emanate. It includes in addition to the incandescent surfaces near the arc, all those portions of the carbons which are heated, either by conduction or by the current. Were the distribution of total radiation in the vertical plane identical with that of the light-giving rays, the measurement of their ratio with the axis of the thermopile in any plane which passes through the arc would give us the efficiency of the lamp, but the curve of distribution of total intensity is not the same as that of candle-power, and the ratio in question is a function of the angle which the axis of the pile makes with the horizon. It becomes necessary, therefore, to make an exploration of the entire zone through which the lamp sends out rays, determining the ratio of luminous to total radiation for each angle and then to integrate the results."*

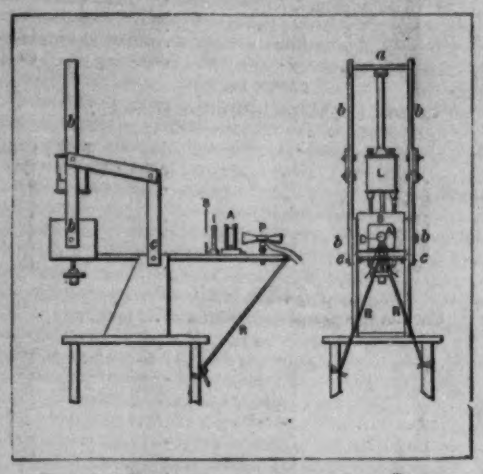


FIG. 2.—EFFICIENCY OF THE ARC LAMP.

With such an object in view the piece of apparatus which is shown in Fig. 2 was devised. The lamp was hung from a horizontal beam (*a*), supported by two upright pieces (*b b*), which could be kept always vertical by means of a "parallel motion" arrangement. The alum bath (*A*) and the thermopile (*P*) were also carried upon a board, pivoted at (*c c*), so that it could be turned to any desired angle. All necessary changes of angle could be made without altering the distance between the arc and the thermopile, or the relation of the alum cell to either of them. By means of this apparatus measurements were made at angles of 0°, 10°, 20°, 30°, 40°, 50°, 60° and 63° below the horizontal planes. The following carbons were used:

(1) Uncoated carbons.....diameter = .832″
(2) " " ..... " = .563″
(3) Copper-plated carbons..... " = .500″
(4) " " ..... " = .450″
(5) Uncoated carbons..... " = .370″
(6) Copper-plated carbons..... " = .250″

The results of these measurements are given in tables 2, 3, 4, 5, 6, and 7, and curves showing the distribution of luminous and total radiation, emanating from the lamp under the above conditions, are given in Figs. 3, 4, 5, 6, 7 and 8.

The radii show the positions for which measurements were taken and distances measured along these lines from the origin to each curve give the intensity of luminous and total radiation in each position. The curves of luminous radiation are similar in form to those of candle-power. Note, for purposes of comparison, the set of curves of candle-power at various angles published by M. Schreihage,† of the Polytechnic School at Braunschweig, who has made extended measurements of lamps with different sizes of carbons. In the following tables *D* is the deflection for total radiation, *d* that for light-giving radiation (corrected).

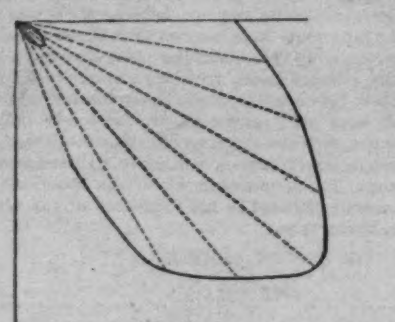


Fig. 3.

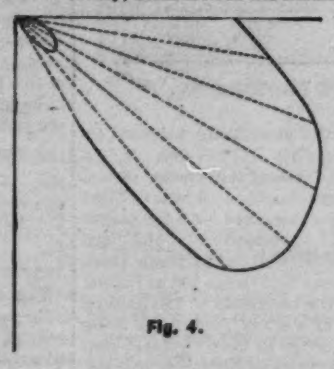


Fig. 4.

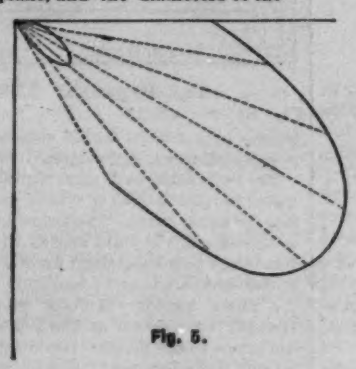


Fig. 5.

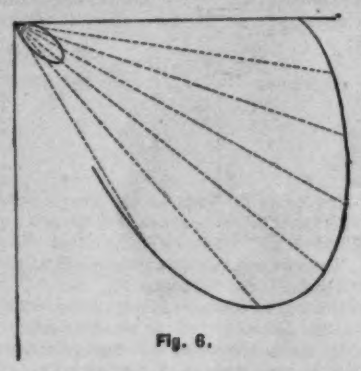


Fig. 6.

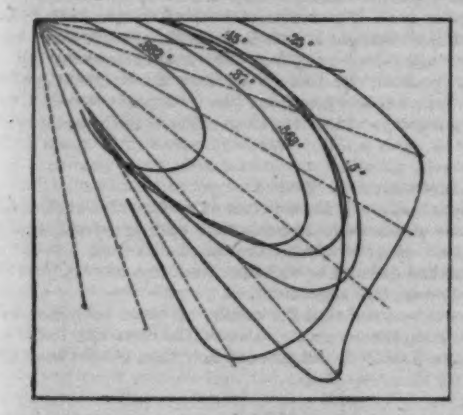


Fig. 9.

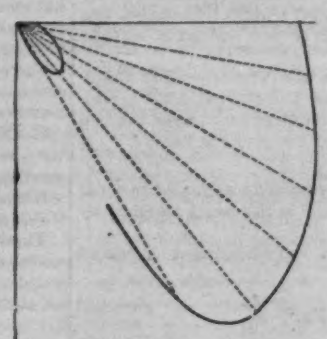


Fig. 7.

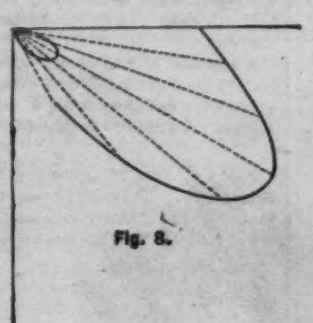


Fig. 8.

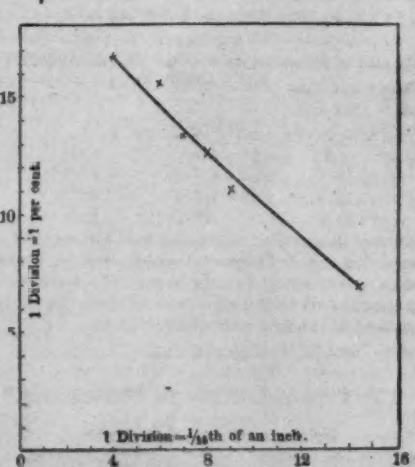


Fig. 10.

FIGS. 3, 4, 5, 6, 7, 8, 9 AND 10.—EFFICIENCY OF THE ARC LAMP.

TABLE II.

Carbon (unplated), diam. = .832 inch.

Angle	d	D	d/D	P. D. (Volts).
0°	4.	220	.0182	44
10°	6.8	265	.0256	42
20°	16.4	300	.0547	42
30°	27.3	350	.0780	40
40°	35.1	390	.0900	40
50°	27.3	330	.0827	38
60°	20.3	300	.0677	39
63°	5.4	125	.0432	39

* A paper read before the American Institute of Electrical Engineers, New York, May 22, 1889, with an introductory note by Edward L. Nichols.

† The Efficiency of Methods of Artificial Illumination. Transactions of the American Institute of Electrical Engineers, Vol. 6.

‡ Ernest Merritt: Some Determinations of the Energy of the Light from Incandescent Lamps. *American Journal of Science*, Vol. 37, p. 167.

§ John Ericsson in his "Contributions to the Centennial Exhibition," 1876, says that the caloric energy imparted to a thermopile is not proportional to the arcs through which the needle of the galvanometer sweeps, as stated by Melloni, but that for deflections not exceeding 15 degrees, the caloric energy imparted to the pile by radiant heat is very nearly as the square root of the versed sine of the angle of deflection; the deflection of the needle at the termination of the first degree exceeding the energy transmitted, in the ratio of 100 to 89, and beyond 90 minutes the energy becoming greater than the deflection in a constantly increasing ratio. Ericsson does not state, however, what kind of galvanometer he used in his investigations. The one used by me was a low resistance reflecting galvanometer of Sir William Thomson's pattern. It had been tested by Mr. Merritt, who found that the deflections were proportional to the energy imparted to the pile. In my experiments this proportionality was assumed to be true.

* Edward L. Nichols. l. c.

† Schreihage, Centralblatt für Elektrotechnik, No. 22, 1883. See also La Lumiere Electrique, T. 29, p. 585.

TABLE III.

Carbon (unplated), diam. = .563 inch.

Angle.	d	D	$\frac{d}{D}$	P. D. (Volts).
5°	6.8	165	.0412	41
10°	10.8	195	.0554	42
20°	22.9	245	.0956	43
30°	32.8	264	.1242	39
40°	39.2	274	.1441	42
50°	28.4	252	.1137	41
60°	10.8	128	.0825	40

TABLE IV.

Carbon (copper plated), diam. = .5 inch.

Angle.	d	D	$\frac{d}{D}$	P. D. (Volts).
0°	5.4	110	.0491	45
10°	12.2	140	.0872	45
20°	21.5	172	.1250	45
30°	29.7	190	.1563	45
40°	33.8	195	.1733	45
50°	20.3	155	.1310	45
60°	4.1	93	.0441	45

TABLE V.

Carbon (copper plated), diam. = .45 inch.

Angle.	d	D	$\frac{d}{D}$	P. D. (Volts).
0°	10.8	197	.0548	45
10°	20.3	225	.0901	45
20°	29.7	242	.1228	45
30°	39.2	260	.1506	45
40°	41.9	270	.1552	45
50°	27.3	255	.1059	45
60°	12.2	180	.0676	45
63°	5.4	110	.0492	45

TABLE VI.

Carbon (unplated), diam. = .37 inch.

Angle.	d	D	$\frac{d}{D}$	P. D. (Volts).
0°	10.	180	.0555	40
10°	14.9	190	.0789	42
20°	24.4	200	.1220	38
30°	31.8	217	.1474	37
40°	39.2	230	.1696	40
50°	42.	240	.1750	42
60°	33.8	205	.1659	42
63°	10.8	115	.0869	38

TABLE VII.

Carbon (copper-plated), diam. = .25 inch.

Angle.	d	D	$\frac{d}{D}$	P. D. (Volts).
0°	13.5	160	.0844	37
10°	22.9	185	.1238	37
20°	39.2	225	.1742	39
30°	45.9	255	.1800	38
40°	41.9	230	.1822	38
50°	29.7	150	.1980	39
60°	4.1	75	.0547	38

The distribution of total radiation differs widely from that of luminous radiation, so that the efficiency expressed by their ratio depends upon the angle of measurement. The values of the efficiency in each case for the various angles at which measurements were made have been calculated. They are shown in the diagram of efficiencies in Fig. 9.

In order to determine the mean or "hemispherical" efficiency of the lamp the ratio of the radii of two semi-circles, the areas of which equal the areas of the curves of total and luminous radiation was found by means of a planimeter. The following are the values thus obtained:

TABLE VIII.

Diameter of carbons.	Spherical efficiency.
.832	.0687
.563	.1100
.500	.1266
.450	.1336
.370	.1554
.250	.1660

The above table forms the basis of the curve shown in Fig. 10, which represents the relation between the diameter of the carbons and the "hemispherical" efficiency of the lamp. The diagram is a straight line. Thus we see that the hemispherical efficiency varies inversely as the diameter of the carbon.

It will be interesting to compare this with the result of M. Schreihage's experiments. He measured the mean spherical candle-power with the different sizes of carbons, and found the same relation to hold true, as will be seen from the following table:

TABLE IX.

M. SCHREIHAGE'S MEASUREMENTS OF CANDLE-POWER AND CURRENT DENSITY.

Cross-section of positive carbon. mm.	Diameter d. m.m.	Spherical c. p.	d. × c. p.	Current density.
40	7.12	417	3,353	0.134
95	11.0	383	4,128	0.066
134	13 6	254	3,462	0.047
194	16.1	189	3,045	0.032
254	18.0	161	2,905	0.25

M. Schreihage states that this relation is not completely satisfied in the case of the mean horizontal candle-power, especially when the carbons are very small or very large. We have seen that this statement applies also to the experiments upon the horizontal efficiency described in the first part of this paper.

The Personal Error in Photometry.*

BY PROF. EDWARD L. NICHOLS.

Whenever, in the course of photometric work, different observers have occasion to compare the same pair of lamps, it will be found that the result of their readings with the Bunsen photometer differ by an amount very much larger than the apparent mean error of a single observation.

Ordinarily, these differences are cloaked by the accidental errors due to the fluctuations of the lights under observation, and they have, consequently, not received the attention which they merit. There has been, indeed, so far as I know, no systematic attempt to determine the precise nature and importance of this personal error, the existence of which has doubtless been recognized by very many observers.

The introduction of the storage battery and the adoption of the incandescent lamp, supplied from the constant source thus afforded, as a secondary standard, has, however, entirely removed the large accidental errors resulting from uncontrollable fluctuations in our standard of illumination, and the personal errors just alluded to accordingly stand out in their true importance. I have very recently had occasion to make some experiments upon this subject, the results of which may be of some interest to those who have occasion to work with the Bunsen photometer.

The character of the errors with which one meets continually, whenever the reading of two or more observers are brought into direct comparison, may be very well shown by means of two sets of readings made by Mr. B. W. Snow and myself upon the same pair of lamps. These observations were made under precisely similar and uncommonly favorable conditions. The two lamps in question were of the same type, and being the only lamps in circuit with a large storage battery, they could be maintained at an almost absolutely constant voltage. These two sets of readings are not presented here as an example of what may be done with the Bunsen photometer in the comparison of constant sources of light. They are indeed of no great accuracy, and contain larger accidental errors than some observations to which I shall have occasion to call attention presently. They exhibit, however, very clearly the existence of the personal errors of observation which are to form the subject of this paper.

TABLE 1.

Two parallel sets of ten readings upon the candle-power of an incandescent lamp.

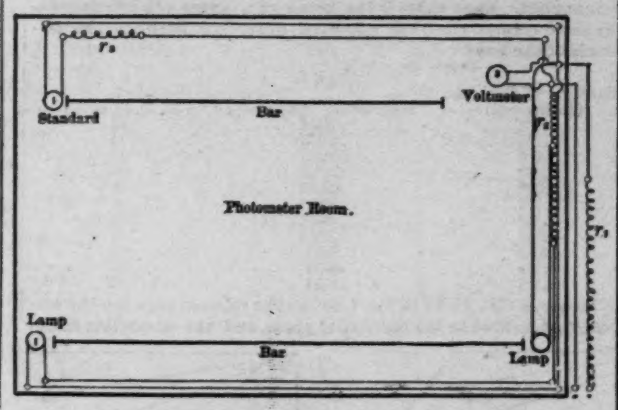
(1) (B. W. S. observing). Readings. C. P.	Differences. C. P.	P. c.	(2) (E. L. N. observing). Readings. C. P.	Differences. C. P.	P. c.
12.12	.112 =	.91	12.56	.044 =	.35
12.32	.088 =	.72	12.60	.084 =	.67
12.16	.072 =	.59	12.36	.156 =	1.25
12.16	.072 =	.59	12.56	.044 =	.35
12.28	.048 =	.39	12.64	.124 =	.99
12.40	.168 =	1.38	12.60	.084 =	.67
12.28	.048 =	.39	12.56	.044 =	.35
12.08	.152 =	1.30	12.40	.116 =	.93
12.12	.112 =	.92	12.72	.196 =	1.35
12.40	.168 =	1.24	12.56	.044 =	.35
AVERAGES.					
12.232	.104	.852	12.516	.089	.717

It will be seen from the above table that while the apparent mean error of a single observation is only about one-tenth of a candle, and the probable error of each set only .022 candle, the two averages themselves differ by .284 candle.

The following experiments were made for the purpose of determining the nature of this personal error:

Three incandescent lamps of the same type and voltage were selected, care being taken to choose specimens the carbons of which were as straight as possible. These lamps gave 16 candles at 110 volts. They were connected in multiple to the terminals of a storage battery giving a potential difference of 120 volts. Adjustable resistances of German silver wire were placed in the line leading to each lamp and in one of the mains leading from the battery. (See Fig. 1.)

The lamps, together with the above-mentioned resistances, were set up in a photometer room which contained two Bunsen photometers. The connecting wires were of such length that the lamps could be moved from one photometer bar to the other without breaking connections. One of the lamps was set up as a comparison standard at the end of the shorter bar. Each of the other lamps was then compared with this standard, the resistances being adjusted until these lamps were found to bear the same relation as to brightness to the standard. In other words they were brought to the same intensity by a method which eliminated the systematic personal errors which it was my purpose to study.



THE PERSONAL ERROR IN PHOTOMETRY.

The two lamps were then placed at the ends of the longer photometer bar, the length of which was 400 centimeters. It was divided into 800 equal parts. The lamps had been measured with the planes of the filament at right angles with the photometer bar, and care was taken in setting them up in their new position, to place them at the same angle and presenting the same face to the bar as before.

A closed circuit voltmeter between the terminals of the battery enabled the observer at the beginning of a set of readings to bring the lamps to the proper potential. In order to insure greater constancy in the degree of incandescence throughout the series of tests, the lamps were maintained at a potential considerably below the normal, their candle-power being about twelve instead of sixteen candles.

A number of observers, all of whom were accustomed to photometric measurements and some of whom had had extended experience, were asked to make a set of ten readings each, upon the two lamps. The results of these two readings are given in Table 2.

TABLE 2.

Ratio of two incandescent lamps, previously adjusted to equal brightness. The measurements are made in the usual manner, by means of the Bunsen photometer.

I_r and I_l are the intensities of the right-hand and left-hand amps respectively.

Observer.	Ratio. $\frac{I_r}{I_l}$	Personal error.
A	1.0590 ± .0040	— .0558
B	0.9701 ± .0044	+ .0331
C	1.0021 ± .0022	— .0189
D	1.0191 ± .0072	— .0159
E	1.0182 ± .0030	— .0150
F	1.0002 ± .0057	— .0870
G	1.0733 ± .0053	— .0701
H	1.0293 ± .0042	— .0261
I	1.0297 ± .0050	— .0263
J	1.0220 ± .0027	— 0.188

The true value of the ratio, $\frac{I_r}{I_l}$, determined previously by comparing each lamp separately with the standard, was .0032 + .0015, which value was used in computing the "personal" error.

It will be seen from inspection of the table that none of the averages fall at the middle of the bar, nor are they distributed around it in such a manner that the most probable value of the entire series, calculated by least squares under the assumption that only fortuitous errors exist, approximates to unity as it should do, were the lamps of equal brightness and were there no systematic errors to vitiate the result. On the other hand the readings lie, with a single exception, on one side, namely to the left hand of the centre of the photometer bar. It will be seen, moreover, that the probable error calculated for each set separately, without taking cognizance of any systematic error, is very small in comparison with the differences between the mean results of the various sets, and especially in comparison with the variations of those averages from unity.

The Bunsen disc with which these observations were made was mounted in the usual manner, the two sides of the disc being viewed simultaneously by means of two plane mirrors set at the proper angle behind the former. It was noted that the almost universal habit in reading was to use the two eyes independently, one eye fixed upon each side of the disc. It seemed probable, therefore, that the personal error arose from the unequal sensitiveness of the observer's eyes, in that he would unconsciously set the disc at too great a distance from the lamp which illuminated the side of the disc which was being observed by his more sensitive eye. It appears, if we accept this explanation, that the right eye was the more sensitive in all the cases under observation excepting one, that of the writer (see Table 2 B), whose readings would indicate the opposite peculiarity.

In order to reverse the relation of the observer to the photometer bar, without altering any of the other conditions of measurement, a large mirror was set up opposite the photometer at a distance of about 40 centimetres. The observer, by sitting with his back to the bar, could then see the images of the Bunsen disc in the mirror, and his right and left eyes were reversed with reference to the lamps. Sets of ten readings were made in this manner by some of the same observers as before, the object being to test the hypothesis just stated. The results thus obtained were, however, complicated by the unforeseen circumstance that the method of using the eyes in observation was not the same when the image of the disc was seen in the mirror as when it was viewed directly. The observer, when using the mirror, no longer used his eyes independently, but scanned the image as a whole, so that both eyes had a share in determining the brightness of each side of the disc. The result was to produce a change in his settings, not by introducing a systematic error, equal and opposite to that occurring in the first series of observations, as had been expected, but by eliminating the error in question. In a word, the settings with the mirror were in better agreement than those made by direct observation, and they gave results much more nearly in accordance with the known equality of the lamps.

In my own case, however, an exception to the above statement must be noted. Very possibly as the result of an effort to repeat with the mirror the precise method of observation followed in making the direct settings, I continued to use my eyes independently, viewing the image of one side of the disc with the right eye, the other with the left. There resulted a set of readings, such as I had expected to obtain from all the observers, the mean of which lay as far from the center of the photometer bar as the mean of the direct readings, but upon the other side. (Compare sets "B," Tables 2 and 3.)

The results obtained with the mirror are given in the following table:

TABLE 3.

Ratio of the two lamps, determined by observing the images of the Bunsen disc in a large mirror; the observer placed with his back to the photometer bar:

Observer.	Ratio. $\frac{I_r}{I_l}$	Personal error.
A	1.0070 ± .0026	.0028
B	1.0444 ± .0011	.0414
C	0.9964 ± .0053	.0068
F	1.0141 ± .0025	.0109
G	1.0004 ± .0056	.0028
H	1.0134 ± .0045	.0102
I	1.0004 ± .0031	.0028

The observations with the mirror were followed by four sets of direct readings made with one eye bandaged. It was found that although more fatiguing, these monocular settings were made with a feeling of certainty on the part of the observer which had not accompanied the settings made with both eyes. In the latter case, indeed, a conflict between tendencies to set the disc in two distinct positions had been very apparent, the observer unconsciously choosing now one, now the other, as the true positions. The set of readings, given in full in Table 4, will serve to illustrate the result of this tendency. The instances in which the observer seems thus to have temporarily changed in his judgment of the true setting, are printed in heavy type.

TABLE 4.

No.	Reading.	No.	Reading.
1	1.033	6	**1.048**
2	1.022	7	**1.053**
3	1.021	8	1.023
4	1.023	9	1.033
5	**1.050**	10	1.030

This tendency to vacillation disappeared almost entirely when only one eye was used. The readings obtained with a single eye not only agreed much better among themselves than those made under like conditions using both eyes, but the result obtained with the left eye were identical with those obtained with the right eye, and both seemed to be entirely free from the systematic personal error that had been found to vitiate readings made in the usual way.

The results of such a set of monocular readings, made by Mr. Snow and myself, all other conditions remaining the same as in previous trials, are given in Table 5.

It will be seen that the probable error of each set is much smaller than in the sets of observations made with both eyes; also that the readings of two observers, whose mean results from similar sets with both eyes had differed by eight per cent. (see sets "A" and "B," Table 2), are in complete agreement.

Finally, it will be noted that the results of these four monocular series differ from the accepted value of the ratio of intensities of the two lamps (1.0032) by an amount less than the probable error of each set.

TABLE 5.

Observer.	Eye used.	Ratio.	Personal error.
B. W. S.	(Right.)	1.0028 ± .0019	.0004
B. W. S.	(Left.)	1.0001 ± .0019	.0031
E. L. N.	(Right.)	1.0001 ± .0017	.0031
E. L. N.	(Left.)	1.0031 ± .0018	.0001

It had been my intention to extend the experiments described in this paper to a much larger number of observers.

The evidence obtained, however, seemed quite sufficient to establish the existence of the personal error in photometry, and to show that it was in general very far from being a negligible quantity. Frequent repetitions showed, that in my own case at least, the error was very nearly constant, and I think that it would be quite possible to establish a personal equation, and to apply the proper correction.

A much better plan, however, would be to so modify the photometer car itself as to insure the use of both eyes in the inspection of each side of the illuminated disc. Several forms of photometer, already described, partially fulfill the necessary requirement. Any device which would bring the images of the opposite faces of the disc into a vertical line in the field of view would doubtless serve to eliminate the error in question. Observations with such a photometer would correspond in character to the "monocular" readings given in Table 5. Not only would they be free from the systematic error to which the ordinary form of Bunsen photometer is subject, but the accidental errors would be much smaller, and the degree of uncertainty which attends the determination of candle-power by our present methods would be in great measure diminished.

* A paper read before the American Institute of Electrical Engineers, New York, May 22, 1889.

Magnetism in its Relation to Induced Electromotive Force and Current.*

BY ELIHU THOMSON.

There is perhaps no subject which at the present time can have a greater interest to the physicist, the electrician, and the electrical engineer than the one which heads this paper. The advances which have been made in the study from its purely theoretical or scientific side, and the great technical progress in the utilization of the known facts and principles concerning magnetic inductions, can but deepen and strengthen that interest.

On the side of pure theory we find the eager collection of experimental data to be submitted to the scrutiny of the ablest and brightest minds, to be examined and reasoned upon with the hope of finding some clue to satisfying explanations, and, on the side of practice, we find the search for new facts and relations no less diligent, though often stimulated by practical problems presented for solution. Indeed, the urgency for results is often the greater on the practical side, for theory can wait, practice cannot, at least in the United States.

We must look for continued triumphs in both directions, and the most welcome of all will be the framing of a theory or explanation which will enable us to interpret magnetic and electric phenomena. The recent beautiful experiments of Herts on magnetic waves have opened a fertile region for investigation.

It would seem that the study of magnetism and electricity will give us the ability to investigate the ether of space which medium has been theorized upon at great length, with the result of leaving it very much where it was before, a mysterious necessity.

Faraday says, speaking of magnetism:

"Such an action may be a function of the ether, for it is not at all unlikely that if there be an ether it should have other uses than simply the conveyance of radiations." 3,075. Vol. III., Exp. Res.

"It may be a vibration of the hypothetical ether, or a state of tension of that ether equivalent to either a dynamic or a static condition, etc." 3,263. Vol. III., Exp. Res.

Faraday again says, speaking of the magnetic power of a vacuum:

"What that surrounding magnetic medium deprived of all material substance may be I cannot tell, perhaps the ether." 3, 277. Vol. III., Exp. Res.

Modern views would seem to point that through a study of magnetic phenomena we may take a feeble hold upon the universal ether. Magnetism is an action or condition of that medium, and it may be that electrical actions are the expression of molecular disturbances brought about by ether strains or interferences. The close relations which are shown to exist between magnetism and light tend to strengthen such views. Indeed it would not be too much to expect that if the mechanics of the ether are ever worked out we should find the relation between sensible heat and electric currents to be as close as that of light to magnetism, perhaps find ultimately the forms of matter, the elements and compounds to be the more complex manifestations of the universal medium; aggregations in stable equilibrium. It is a difficult conception, I confess, and a most shadowy and imperfect one, yet facts and inferences which favor such views are not wanting.

Our science of electricity seems almost to be in the same condition that chemistry was before the work of Lavoisier had shed its light on chemical theory. Our store of facts is daily increasing, and apparently disconnected phenomena are being brought into harmonious relation. Perhaps the edifice of complete theory will not be more than begun in our time, perhaps the building process will be a very gradual one, but I cannot refrain from the conviction that the intelligence of man will, if it has time, continue its advance until such a structure exists.

I have been led to make these general allusions to electrical theory in order to emphasize the fact that in the present paper no unravelling of the mystery is to be attempted, but rather the presentation of some few considerations upon a subject of absorbing intcrest.

The conception of Faraday in regard to the existence of lines of magnetic force representing directions of magnetic strain or tension in a medium has not only lost nothing of its usefulness up to the present time, but has continually been of great service in the understanding of magnetic phenomena. We need spend no time in showing, as Faraday and others have done, that these lines are always closed circuits, polarized so that the direction of the lines cannot be reversed without reversal of the actions. Nor need we take time to show that in any medium the lines are mutually repellant laterally if of the same direction of polarization. Opposing this tendency to separation or lateral diffusion of magnetic force is the strong apparent tendency of the lines to shorten themselves in any medium. These actions are disturbed by the presentation of a better medium, as iron instead of space or air. Lines of force will move into the better medium, having apparently the constant tendency to diminish the resistance in their paths.

The peculiar and mysterious nature of media such as iron is to permit an extraordinary crowding of lines on account of slight resistance to their passage through it. We need not, in addition, do more than refer to the other well-known facts of an electric current developing magnetic lines encircling the conductor, as being the general type, which includes all forms of magnetic field, or electromagnets, sustained by currents, and the fact of a development when magnetic lines or circuits and material masses are in relative movement of electromotive forces transversely to the direction of the lines of magnetism and also transversely to the direction of relative movement, as in the case of electric conductors traversing or cutting through a field, or of a field traversing or being moved across a conductor. We must not forget that even insulators, as well as conductors, cutting lines of force, have the electromotive force developed in them. The action simply develops potential difference, and this generates the current where a circuit exists. While we are in the habit of saying that a conductor moved across a field of lines, or *vice versa*, generates electric current, I think the statement incomplete. The movement only sets up a potential difference and the power expended in effecting the movement generates $C \times E$. The current is energy less the potential, or the energy expended gives the two effects of potential or pressure, and current or rate of movement. Consequently an insulator, or an open-circuited conductor, traversing a field, consumes no energy, potential difference only being produced. Nevertheless, as will be shown, the magnetic circuits or lines themselves may furnish the energy for their own movement across a conductor, and so develop current as well as potential. This occurs in the effort of lines to shorten their paths, to lessen their density, to pass to better media. Indeed, a close examination will show that wherever power is expended in developing current in a circuit, cutting lines of force, the energy expended is first employed in stretching the lines, which thus receive the energy required to permit them, in shortening, to cut the conductor and set up currents in the electric circuit in accordance with the potential difference developed in that circuit and its resistance.

I think, we may also say, though I do not remember to have seen the statement so put, that whenever electric potential is set up inductively, as in self-induction, mutual induction, induction from one circuit to another and induction from magnets or magnetic field, it is set up by the movement of lines of force laterally across the body, mass or conductor in which the potential is developed, and that whenever current is set up in a wire or an existing current prolonged, or an existing current checked by induction, self-induction or induction from magnets, the action is a transfer of energy, represented by strained lines of force shortening or lessening their resistance, or lengthening and increasing the resistance in their paths. The magnetic field is like an elastic spring, it can in one condition represent stored energy—it can be strained and will store energy—it can be made to relieve its strain and impart energy.

Let us examine some known phenomena in this light. Take the case of a simple wire, conveying current say in a line away from observer, Fig. 1. There exists a free field of circular magnetism (so-called), shading off away from the wire and which is represented by concentric circles of increased diameter. The superior intensity or strength of the lines near the wire may also be represented by their thickness. This is often shown also by crowding the lines near the wire, though I am disposed to regard Fig. 1 as more nearly expressing the condition, unless we are to regard the lines as simply indicating a sort of atmosphere of magnetic effect whose density becomes less as we proceed outward from the wire, in which case either form of symbol suffices. The direction of polarization of the lines may be indicated by an arrow head pointing in a direction of right-handed rotation in the path of the lines. This is the typical figure or expression for all forms of simple magnetic circuit—the form of the lines, their length, position, density, will depend on the shape of the conductor or conductors (when more than one) and the materials surrounding or in proximity to the wire or wires.

If the current traversing the conductor is constant, the magnetic field around it is stable and static, unless other influences come in to modify it. The cutting off of the current is followed by instability of the field whereby it can and must produce dynamic effects. I say *must* because the field represents stored energy and in disappearing *must* give out that energy. To throw light on this part of the subject is one of the objects of the present paper. Cutting off the current supply in the case assumed leaves the developed magnetic lines or strains unsupported, they at once shorten their paths or circuits, collapsing upon the conductor as it were, and continuing this action, cut the section of the conductor, and apparently disappear in magnetic closed circuits of infinitesimal diameter but of great strength of polarization. It appears to me that we must either be prepared to give up the idea of lines of force or take the position that the magnetic circuits precipitate themselves in shortening their circuits and disappearing upon and cut the conductor. It was Hughes who put forward the idea that an iron bar in losing its apparent magnetism really short circuits the lines in itself as innumerable strongly magnetized closed circuits among the molecules. In becoming magnetic once more these short circuits are opened or extended into the air by some source of energy applied to strain the lines, such as a current in a conductor around the bar.

May not this idea be extended, then, to include the magnetic medium, the ether itself? Does it contain intensely polarized closed circuits of magnetism which are ready to be stretched or extended under certain conditions by the application of energy, which energy is returned by the collapse of the extended circuits? This is doubtless but a crude expression of the real condition of things, for the lines are only symbols for a condition of strain in a medium which cannot be represented in thought, as we know nothing of its real nature. There is one point in this connection which I must emphasize. The strained lines, Fig. 1, are indications of stored energy in the ether, and the lines *cannot* disappear without giving out that energy. Ordinarily, it makes its appearance as the extra-current, and adds itself so as to prolong the current which extended the lines when an attempt is made to cut off such current. Were it conceivable that the current could be cut off and the wire put on open circuit while the lines still remained open or strained, the energy must still escape when the field disappears. It would then produce such a high potential as to be able to discharge from the ends of the conductor, and if the conductor were of some section, part of the energy would be expended in setting up local currents in it. The field could not disappear without an outlet for the energy it represents. But we cannot cut off a current in a wire so as to leave the wire on open circuit with the lines of the magnetic circuit remaining around it without iron or steel or the like in the magnetic circuit. We can approach that condition, however, by breaking the circuit very quickly with a condenser of limited capacity around the break. This is done in the Ruhmkorff coil primary; the condenser forms a sort of blind alley for the extra current on its beginning to flow out of the primary coil. But the condenser charges and backs up and stops the discharge from the primary, even giving a reverse current. The lines of magnetic force collapse, however, and have their effect in the enormous potential set up in the secondary coil.

Take away the secondary coil so as to stop that outlet, the energy expends itself on the iron core and the primary coil. Take away the iron core and the energy of magnetization of the air or ether core expends itself on the wire of the primary and, possibly, also on the dielectric of the condenser to some extent. The extra current becomes in this instance an oscillatory discharge of very high period back and forth through the primary coil from the condenser, until the energy is lost in the heat of $C^2 \times R$. This conversion is doubtless rendered all the more rapid by uneven distribution of current and eddy current set up in the wire of the coil.

The considerations just given concern the loss of field or the shortening and apparent disappearance of the magnetic lines or circuits, as giving rise to the self induction or increased potential on breaking. Where the energizing current is slowly cut off or diminished the energy is gradually transferred to the wire in producing elevation of potential during the decrease; and the collapse and cutting of the wire by the collapsing circuits or lines is then only more gradual.

Let the current be returned to the wire after disappearance of magnetism and the lines again seem to emanate from the wire and at the same time cut it and produce a counter potential in it, which is the index of the abstraction of energy from the circuit, and its storing up in the form of elastically strained lines of magnetism around the conductor. The effect is that of self-induction on making or upon increase of current, the measure of the amount being the energy stored in the magnetic circuits which have been extended or opened up by the current. The greater the current and the shorter the path for the lines developed around the axis of the conductor, the greater the energy stored up. Hence, a circular section conductor has the highest self-induction, a tube of same section less as its diameter increases, a flat strip has less as its width increases and thickness diminishes, a divided conductor much less than a single conductor of same shape and section. Separating the strands of a divided conductor increases the length of magnetic paths around it and so diminishes the self-induction. A striking instance of this latter fact was developed in conveying very heavy alternating currents of very low potential a distance of about three feet by copper conductors, the current being used in electric welding operations.

The conductors were built up of flat thin strips of copper for flexibility. When the strips were allowed to lie closely together the short conductor showed an enormous self-induction which cut down the effective potential at its ends near the work. By spreading apart the strips so as to lengthen a line around the conductor, the self-induction could be easily made less than 35 per cent. of what it had been before. The interweaving of the outgoing and return conductor strands as one compound conductor, gets rid almost entirely of the self-inductive effects, because neither conductor has any free space in which to develop strong magnetic forces, but is opposed in effect everywhere by the opposite current in its neighbor.

Where a number of conductors are parallel and have the same direction of current, as in a coil or in a strand, it is evident that statically the conductor may be considered as replaceable by a single conductor with the same external dimensions and same total current in the area occupied, the magnetic forces or lines surrounding them being of same intensity. But with changing current strength the distribution of current in the conductor has also a powerful effect on the energy absorbed or given out in accordance with the magnetism produced. Hence the self-induction of a strand, coil or conductor of the same section varies with the rapidity of current changes, owing to the conduction being uneven.

The uneven distribution of current, or its tendency to flow on the outer parts of a conductor when the rate of variation or alternation is made great, is in itself a consequence of the fact that less energy is transferred into magnetism in this case, than when the current flows uniformly over the section or is concentrated at the centre. In other words, when a uniform current traverses a conductor of the same section the circular magnetism or surrounding magnetic lines are to be found not only outside the conductor, but also beneath its exterior. Since in forming these lines on passage of current the middle of section would be surrounded by more lines than any other part of the conductor, the current tends to keep out of that part and move near the exterior in greater amount. Hence in rapidly alternating currents the conductor section is practically lessened, being restricted largely to the outer metal of the conductor. If the round conductor, Fig. 2, were made of iron, the magnetism interior to it and set up by a current in it would be very much greater, the section of the conductor being filled with magnetic circuits or lines around the centre. The total magnetism, external and internal, would be much greater in this case for a given current flow, and the energy absorbed and given out in formation and loss of field or the self-induction would be much increased. This could, however, be greatly diminished by slitting the conductor radially or making it of a number of separate wires out of lateral magnetic contact, one with the other, Fig. 3. In these cases the resistance of the interior magnetic circuits would be increased, as there would be several breaks in the continuity around the centre of the conductor. The total magnetism which could be set up by a current would be lessened, and the self-induction, therefore, lessened.

The moment we begin the bringing of iron into proximity with an electric conductor conveying current, we provide a better medium for the flow or development of magnetic lines or circuits. In other words, the lines may then be longer, yet equally intense, or more lines may be crowded into a given section of this metal than in air or space. Figs. *4a*, *4b*, *4c*, show the effect brought about by bringing iron of different forms near to the conductor.

It shows, in other words, the development of the ordinary electromagnet of the horseshoe form, and the concentration of the lines in the better medium. The lines also tend to shorten and diminish the resistance to their passage, so that attraction of the iron to the conductor takes place, and if there is more than one piece of iron they tend to string themselves around the conductor in magnetic contact with one another.

When copper bars of 1 inch diameter are traversed by currents of 40,000 to 60,000 ampères, as in welding them, the magnetic forces just referred to become so enormous that very heavy masses of iron brought up to the bar are firmly held, even though the current be of an alternating character, changing direction many times a second.

When a conductor is surrounded by a cast iron ring, as in Fig. 5, the current in such conductor has an excellent magnetic medium

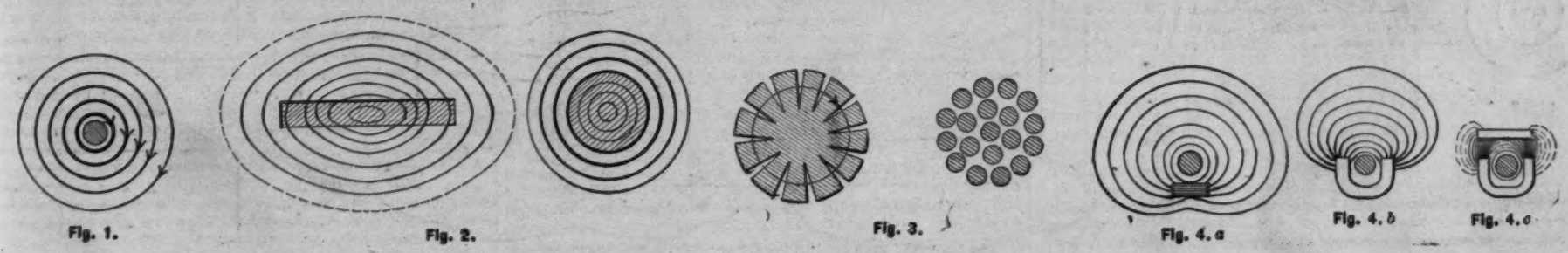


Fig. 1. Fig. 2. Fig. 3. Fig. 4. *a* Fig. 4. *b* Fig. 4. *c*

FIGS. 1, 2, 3 AND 4.—MAGNETISM AND ITS RELATION TO INDUCED ELECTROMOTIVE FORCE AND CURRENT.

* A paper read before the American Institute of Electrical Engineers, New York, May 22, 1889.

surrounding it. A large amount of energy is then abstracted on the first impulse of current, which goes to develop strong and dense magnetic lines through the iron ring and across the gap in it. On taking off the current the energy is returned as extra current, and its force is many times what would be found with air alone surrounding the conductor. We have then greatly increased the self-induction, the storing of energy and opposition to current flow at the beginning, the giving back of energy and assistance to the current flow on attempting to remove or stop the current. Let us now complete the ring by making it of iron, endless, Fig. 6, with the conductor in the middle.

We now find that on passing current through the conductor it meets with a very strong opposing effect or counter potential. The evolution of magnetic lines or the opening out of magnetic circuits goes on at a very rapid rate. Each line or magnetic circuit evolved and cutting the conductor, flies at once outward and locates itself in the iron ring. This ring can carry innumerable lines, and they do not crowd one another. It permits the lines even to lengthen in reaching it, and yet, on account of its low resistance to their passage, the lengthening is equivalent to their having shortened in other media. We will suppose the current not sufficient to exhaust this peculiar capacity for lines which the iron has. Equilibrium is reached, the conductor has opened up innumerable closed circuits and caused them to exist in the ring still closed, but in iron, not space or ether merely. The current passing has continued its action and storage of energy until, to emit another line in view of the resistance now found in the crowded iron ring, is impossible.

Now, let us cut off the current. We are surprised to find a very weak extra current, a practical absence of self-induction on breaking, or at least a giving out of energy in no wise comparable to that on making. Let us put on the current as it was before. Another curious result. But little self induction now on making, energy not absorbed.

Now cut off the current again. Same effect as before. Now let us put on the current reversed in direction. At once we find a very strong counter potential or opposing self-induction developed.

The ring had been polarized, or retained its magnetic energy, and we are now taking out one set of lines and putting in reversely polarized lines of force. This done, we break the reversed current without much effect of self-induction. The ring remains polarized and inert until an opposite flow of current be sent through. Iron is then a different medium from the ether.

The ring once magnetized must in losing its magnetism permit a closure of the lines by shortening. This involves their passage from the iron across the space in the centre of the ring, notwithstanding its great resistance to the lines of force. As passage from iron to air is equivalent to lengthening of the lines it is readily seen that such lengthening may oppose more effect than a slight shortening due to leaving iron, for air or space may give in provoking a closure and disappearance of the lines. Looked at from another standpoint, the lines on the iron may actually require a small amount of initial energy to dislodge them therefrom, so that after being dislodged they may collapse and yield whatever energy they represent.

I must reserve for the future further consideration of the iron ring, but in thinking upon this matter I am led to think that the production of a magnetic line in an iron ring around a conductor may represent a sort of wave of energy, an absorption of energy on the evolution of the line from the conductor and a slight giving out of energy on the line reaching that position of proximity to the iron ring that its passage thereto may said to be a shortening process or a lessening of its resistance.

The magnetism in air, gases and non-magnetic bodies, being assumed to be that of the ether, this medium shows no such effects as those we get with the ring. It does not become permanently polarized, as does even soft iron under the condition of a closed ring. The iron possesses coercive force, or magnetic rigidity, and a steel ring would show more of it. The molecules of the iron or steel take a set. If we were to cut the soft iron ring or separate it in any way, this introduction of resistance of air for ether in the magnetic circuit would cause the lines to collapse and set up a current in the conductor. The energy of the ring would have been restored to the latter. The curious thing is that physically the polarized ring does not present any different appearance or ordinary properties different from those of a plain ring, and will not deflect a compass needle. Its condition is discoverable, however, by the test of self-induction to currents of different direction. As a practical consideration, we may mention in this connection that a self-inductive coil for currents of one direction must be constructed differently from one to be used with alternating currents. The former must have in its magnetic circuit a section of air or the like, or be an imperfectly-closed circuit, as it were. The latter should have as perfectly closed a magnetic circuit as can be made. We see here also the futility of constructing a Ruhmkorff core coil on the closed iron magnetic circuit plan, because the currents in the primary are interrupted, not reversed.

The considerations just put forward in relation to the closed iron ring, and its passive character under the condition of becoming polarized, are more important than at first appears. It has been found that the secondary current wave of a closed iron circuit induction coil or transformer, whose primary circuit receives alternating current, is lagged from its theoretical position of 90 degrees behind the primary wave an additional 90 degrees, so that the phases of the two currents are directly opposed; or the secondary current, working lamps only in its circuit, is one half a wave length behind the primary, instead of only a quarter wave length, as might have been expected.

But when it is understood that the iron core polarized in one direction by the primary impulse does not begin to lose its magnetism when that impulse simply weakens, but waits until an actual reversal of current has taken place, it will be seen that the secondary current, which can only be produced when magnetic lines are leaving the core and cutting the secondary coil or when the lines are being evolved and passing into the core from the primary coil, will have a beginning at the moment the primary reverses, will continue during the flow of that impulse, and will end at substantially the same time with the primary impulse, provided the work of the secondary current is not expended in overcoming self-induction, which would introduce a further lag. Moreover the direction of the secondary current will be opposite to that of the primary, because the magnetic circuits which are opened up by the primary current in magnetizing the core, or which are closed or collapsed by it in demagnetizing the core, will always cut the secondary coil in the direction proper for this result. Transformers of the straight core type with very soft iron in the cores and not too high rates of alternation should approximate more nearly the theoretical relation of primary and secondary waves, because the magnetic changes in the core are capable of taking place almost simultaneously with the changes of strength of the primary current. This fact also has other important practical and theoretical bearings.

Let us assume a plain iron core, Fig. 7, magnetized as indicated, so that its poles *N S* complete their magnetic circuits by what is called free field or lines in space around it. Let a coil of wire be wound thereon as indicated. Now assume that the magnetism is to be lost or cease, either suddenly or slowly. An electric potential will be set up in the coil, and if it has a circuit, work or energy will be produced or given out in that circuit, and in any other inductively related to it. Hence the magnetic field represents work or potential energy. But to develop potential in the wire the lines must cut the wire. This they can do by collapsing or closing on themselves. The bar seems, therefore, to lose its magnetism by gaining it all, and in doing so all the external lines of force moving inward cut the wire. The magnetic circuits shorten and short circuit themselves in the bar, perhaps as innumerable molecular magnetic circuits interior to the iron medium. To remagnetize the bar, we may pass an electric current through the coil. The small closed circuits are again distended, the free field appears, and the lines moving outward cut across the wire coil opposite to the former direction, and produce a counter potential in the wire, and consequent absorption of the energy represented in the free field produced. As before studied, the magnetism cannot disappear without giving out the energy it represents, even though the wire coil be on open circuit, and therefore unable to discharge that energy. The coil open circuited is static, not dynamic. In such assumed case the lines in closing cut the core and heat it. Let us, however, laminate the core or subdivide it as far as possible, and we appear to have cut off this escape for the energy. This is not really so, however. We have simply increased the possible rate of speed of closure, or movement of the lines, and so have increased for the divided core the intensity of the actions of magnetic friction and local currents in the core, the latter still receiving the energy of the magnetic circuit. This reasoning is based on the possibility in this case of cutting off the current in the magnetizing coil and retaining the magnetic field. This is of itself probably impossible with soft iron. That the core receives the energy when the coil cannot is shown in the well known fact that in some dynamos with armatures of bobbins on iron cores, the running of the armature coils on open circuit gives rise to dangerous heating of the cores, and that under normal work the heating is less. In the former case the core accumulates the energy represented in the magnetic changes. In the latter the external circuit of the machine and its wire coils take the larger part of the energy which is expended in doing the work in the circuit. In this case, also, the current in the coils causes a retardation of the speed of change and extent of change of magnetism in the iron cores, which keeps down the intensity of the magnetic reaction. In fact, this retardation or lag and reduction of range of magnetic change may in some machines be made so great by closing the circuit of the armature coils themselves or short circuiting them that the total heat developed in the cores is much less than under normal load.

I wish now, in closing, to refer briefly to phenomena of moving lines of force, and to the effects of speed of movement. In order to generate a given potential in a length of conductor we have choice of certain conditions. We can vary the strength of field and we can vary the velocity. We can use a strong field and slow movement of conductor, or we can use a weak field and rapid movement of the conductor. But we find also that where the conductor has large section it is liable to heat from eddy currents caused by one part of its section being in a stronger field than another at the same time. One part cuts the lines where they are dense and the other where they are not dense, with the result of difference of potential and local currents which waste energy in heat. We cannot make the conductor move in a field of uniform density, because it must pass into and out of the field. The conditions just stated are present in dynamos for heavy current work, where the speed of cutting of lines is low and the armature conductor large in section.

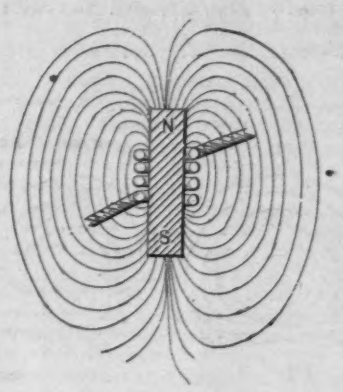
But we find that in a transformer secondary we can use very large section of conductor, even (as in welding machines) 12 to 15 square inches solid copper, without meeting appreciable difficulty from eddy currents in it. The magnetic lines certainly cut the heavy conductor and generate the heavy current and potential needed. What difference, if any, exists? In the transformer the currents are generated by magnetic field of very low density, in which the lines are moving across the conductor with extreme rapidity. The velocity of emanation of lines around the primary coil is probably near that of light, and each line passes across the section secondary conductor in a practically inappreciable time. There is no cause then for differences of potential at different parts of the section heavy secondary. Then to avoid eddy currents in large conductors and generate useful currents in them, we may cause the conductor to be either moved into and out of a low density field with very great speed, or better, we must cause the lines of a very low or diffused field to traverse or cut across the conductor with very high velocity.

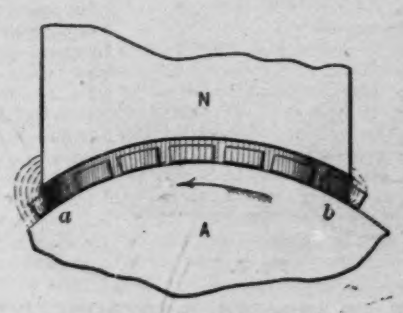
It is a known fact that in dynamos with large section armature conductors there are less eddy currents produced in the conductors when they are provided with iron cores or wound upon iron cores, than when the conductors are made into flat bobbins moved in front of field poles. Projections existing on the armature between which the conductors are placed have a like effect, and enable us to employ heavy bars or bundles of wire without much difficulty from local currents. The reason is simple. In the armatures with coils without iron in them or without projections extending between the turns the conductor moves into and out of a very dense field at comparatively low velocity, so that any differences of potential developed in the parts of the section of conductor have full effect and abundant time to act in setting up harmful local currents. In the cases in which iron projects through the coil or conductor the real action is that the lines of the magnetic circuits move at high speeds across the conductor, and the conductor is at all times in a field of very low density. Figs. 8 and 9 will make this plain. In Fig. 8 we have shown a smooth armature surface having a heavy conductor laid thereon, and which is at *a*, just entering a dense field at the edge of the pole *N* and at *b* leaving such field. It will be seen that when in such position the conductor, if wide, is subjected to varying field strength, and moves at a low speed for the generation of the working potential as it passes through the field, thus giving rise to eddy currents in the conductor.

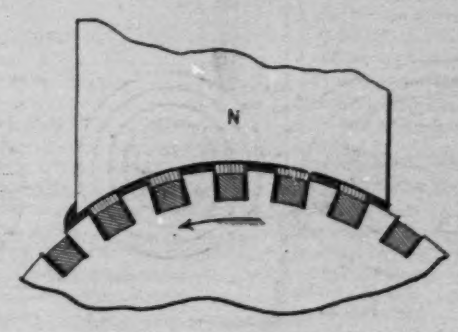
In Fig. 9 the conductors are set down between projections, in which case both armature and field poles are laminated or subdivided. As each projection leaves the edge of field pole *N* the lines which it had concentrated on and through it snap backward at an enormous speed and cross the gap to the next succeeding projection on the armature, cutting the whole section of the heavy armature conductor at practically the same instant. This brisk transfer of lines goes on from each projection to the succeeding one in front of the field pole, leaving a very low density of field at any time between the projections. The best results would be obtained when the armature conductor does not project beyond or quite fill the depth of groove between the projections. Of course there are other remedies for the eddy current difficulty, notably the stranding and twisting of the conductor on the armature so as to average the position of the parts of the compound conductor.

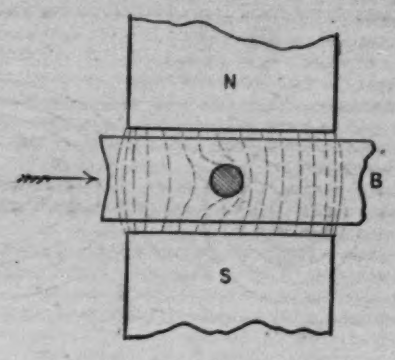
Perhaps the most extreme case of what may be called dilution of field by projections and by closed magnetic circuits in transformers would be that of a block of iron *B*, Fig. 10, moved between poles *N* and *S*, and having a hole through it, into and through which a conductor is carried. The path through the iron is so good that we can scarcely consider that any lines cross the hole from *N* to *S*; yet as *B* moves forward there is a continual snapping transfer of lines from the right forward side of the hole to the left or backward side, cutting the conductor as they fly across, and developing an electromotive force in it. I have described this action more in detail because we have in it whatever distinction in the manner of cutting the lines of the field is to be found between wire on smooth armatures and on projection armatures and modifications thereof; and also between flat, open coils passing through a field and bobbins with cores of iron. The considerations advanced also bring out the relation which exists between closed iron circuit transformers and closed iron circuit (projection) dynamos, as we may call them.

I had intended at the outset of this paper to deal to some extent with the propagation of lines of magnetism undergoing retardation in reference to alternating current motor devices, transformers with limited secondary current, or constant average current, an alternating motor working with what I may term a translation lag, etc.; but it was soon found that these matters must remain over for a continuation of this paper at some future time. My endeavor has been in the present paper to deal with the lines of force theory as though it were a symbol of the reality, but I confess that it is done with many misgivings that I may have carried it too far. Yet, if we are to use the idea at all, it has seemed but right to apply it wherever it may throw any light on the subject or assist in our understanding of phenomena.









FIGS. 5, 6, 7, 8, 9 AND 10.—MAGNETISM AND ITS RELATION TO INDUCED ELECTROMOTIVE FORCE AND CURRENT.

Electric Power in Russia.—The following communication from a correspondent in Russia has an interest peculiarly its own. Referring to the "Memoires sur l'application d'électro magnétisme au movement des machines," our correspondent remarks: ОТО СОУЧНЕНІЕ ООРАТНАО НА НЕІО ВНИМАНІЕ, К ЕМУ ОВІАО НРЕАОСТАВАСНО ВЪ КОНИГСОФУІВ МВСТО ГРАЖКАНСКАГО И НИКЕ Нера.' We are glad to hear of this point in Russian practice, but with regard to the КОНИГСОФУІВ, we think it is exceedingly likely it has already been attempted in England.—*Lond. Electr. Engr.*

In Favor of the Bucket Shop.—Before Judge Tuley, at Chicago, on May 23, Kennedy R. Owen secured an injunction against the Board of Trade and the Western Union and Gold and Stock telegraph companies. Mr. Owen claims in his bill that for years he has done business under the name of Winchester & Co. He did business with a ticker and other telegraph instruments, which brought to his office the condition of the market at the Board of Trade. He is conducting a profitable "bucket shop," against which class the Board of Trade is waging war by threatening to cut off quotations. The injunction was granted on the ground that the Board of Trade, together with the telegraph companies, is building up a great monopoly which is injurious to the people, particularly to the people who do business in "bucket shops."

The Spiral Coil Voltameter.*

BY HARRIS J. RYAN.

During the present year at the Physical Laboratory of Cornell University, the copper voltameter has been used somewhat extensively in laboratory practice by students for calibrating Thomson graded galvanometers, tangent galvanometers, and other electrical measuring instruments where a single determination suffices as a calibration. For practical instruction students are made to check their results on a Thomson gravity balance, and by means of the large galvanometer at the Magnetic Observatory.

The plate form of copper voltameter has been thoroughly and admirably investigated by Mr. Thomas Gray,** of the Physical Laboratory of the University of Glasgow. We are indebted to Mr. A. W. Meiklet and to Lieutenant Anderson ‡ for clear descriptions, based upon the results of Mr. Gray, for the use of this form of voltameter, whereby determinations may be made so accordant that one can scarcely think of more to be desired.

With all this, however, it has been our experience that students are slow to obtain accordant results when making their first attempts to follow Mr. Gray's methods. It seemed desirable to make use of a form of voltameter that required the least consistent time and care to construct and prepare for operation. Again, there should be a wide allowable range of current density, through which deposits would be as firm and adherent as possible. It was with a view of realizing this that we finally adopted and made use of the spiral coil form herein decribed.

A wire coil as a cathode seemed to present many advantages. Wire of high conductivity, good for this purpose, is generally available in any desired size. A wire can be cleaned properly with great ease and readiness by fastening one end in a vice, holding the free part in one hand and sandpapering it with the other. By beginning at the vice to clean it is not necessary to touch the cleaned wire with the hands throughout the complete operation of polishing and coiling into a spiral on a cylinder of the proper diameter, about which has been rolled clean paper. In this manner gain and loss coils are constructed.

Figs. 1 and 2 show the final form of voltameter adopted. The coils are hung vertical. The cathode is made of a smaller diameter and is arranged inside and concentric with the anode. The diameter of the anode is made about 3 c.m. to 4 c.m. larger than that of the cathode. The loss coils prepared as above are ready for use, since for well-known reasons their changes of weight are never accordant. The surface of the gain coil must not be touched by the hand. It is easy to handle it by the extending terminal, by means of which it is suspended in the voltameter. After polishing it is washed by plunging into a jar of water containing a little H_2SO_4.

It is then rolled on filter or blotting paper to remove all but a mere film of the water. The coil is then dipped in 95 per cent. alcohol, removed and the excess of alcohol allowed to drip into the jar of the same. By rolling the coil on clean filter or blotting paper again, nothing but a mere film of alcohol remains, and that is thoroughly evaporated in a few moments, leaving the coil entirely dry.

Coils that have been laid away and become corroded can be readily cleaned, as is well known and directed, by plunging them into a mixture of strong HNO_3 and HCl, one hundred parts of the former to one of the latter, removing them quickly to a distance, such that the vapors of the acid shall not reach the coil during the rest of the preparation. This consists in washing first thoroughly in water, and then proceeding as at first described by plunging in the acidulated water, alcohol, etc. After weighing the coils are ready for the voltameter.

It has been customary with us to use a coil made of two and one-half metres of No. 16 wire, having the surface area of one hundred square centimetres.

For great strenths of current a number of these are arranged in parallel.

For every four ampères one wire is necessary. At the end of the deposit the gain coils are immediately removed, and plunged first into clean water and then into the acidulated, from which they are dried by means of alcohol in the manner above described. When dried they are at once ready to weigh.

The copper sulphate, water and acid, need not necessarily be chemically pure. The density of the voltameter solution should be not less than 1.10 and not more than 1.18.

The question now comes to us as to what degree of accuracy and precision of results we may depend upon from the above form of voltameter.

The successful use of the copper voltameter has come from an appreciation and an understanding of the fact that when copper is immersed in an acidulated solution it passes slowly into solution in an

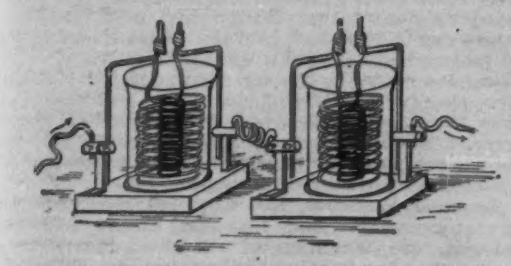


FIG. 1.—THE SPIRAL COIL VOLTAMETER.

irregular way. Mr. Gray has done much work in this particular, and has shown that the going into solution of copper on the cathode is curiously assisted by the current. From the extensive work done with the plate form of voltameter at Glasgow results have been gained with regard to the amount of copper that goes into solution for a certain current density and a certain temperature, that it is a comparatively easy thing to make determinations with assured absolute accuracy to within a tenth or even a twentieth of one per cent. This is remarkable, though nevertheless true.

A Thomson deca-ampère balance was calibrated by means of the copper voltameter under Mr. Gray's directions at Glasgow.

When the same was received and set up at Ithaca in the physical laboratory of the University, it was compared with the large standard tangent galvanometer at the Magnetic Observatory, and found to agree with the same to within one-tenth per cent.

Surely this same or even a greater degree of absolute accuracy could be obtained with less trouble and experience by one making use of the spiral coil cathodes. Mr. Gray has shown that if copper went into solution, unaided by the current, that we could in almost all cases neglect this correction. He has shown us how much it is when a plate is used as a cathode. There are strong reasons, however, for believing than when a wire, which presents a regularly curved surface, is used as a cathode, that the copper from it goes into solution in a more regular way, and that probably in all cases to a considerably lessdegree. Again, by the use of the spiral coil in a voltameter we find an advantage in the fact that the plane of each turn of wire is disposed horizontally, so that by convection the solution is not allowed to become weak near the cathode, nor dense near the anode.

This fact was first pointed out by Mr. Shaw, who speaks of the very accordant manner in which platinum wires disposed horizontally are found to act as cathodes in copper electrolysis.

In a valuable paper by Mr. Shaw* on "The Verification of Faraday's Law of Electrolysis with Reference to Silver and Copper," the very great range of current densities for the deposition of copper on platinum wires of 8 centimetres to 800 centimetres per ampère has been brought to bear on the ratio of silver and copper deposits when the currents are the same. From data taken from this paper, the writer has plotted curves that show the relation of current density to copper deposit throughout Mr. Shaw's work at the Cavendish Laboratory and Emmanuel College.

The work extended over a year, and was done with much care. These curves are shown in Fig. 3. The ordinates represent the

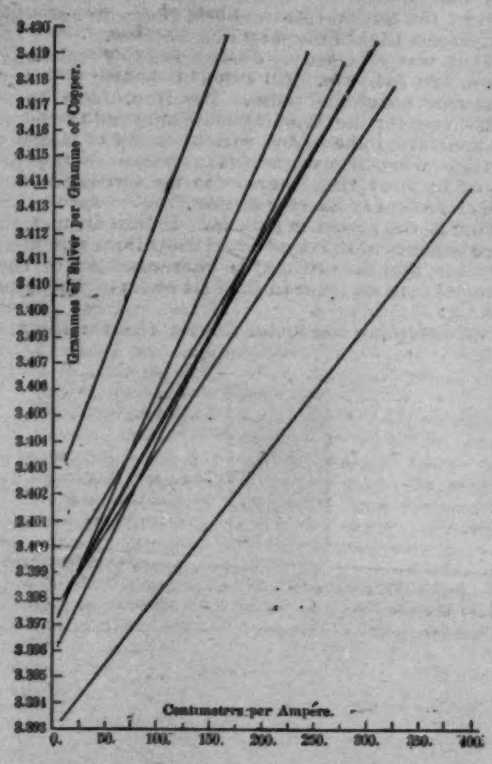


FIG. 3.—THE SPIRAL COIL VOLTAMETER.

amount of silver deposited by the same current that deposits unit weight of copper in a given time, corresponding to current densities, as represented in square centimetres per ampère on the abscissæ axis. As is seen, with the exception of two, the curves are in remarkable accordance, differing by not more than 1-34 per cent. With regard to the two curves that fall above and below the rest, we would say that their position can easily be attributed to accidental causes; the error in the indications of the silver voltameter of a 1-5 of 1 per cent either way would account for their position. Again, Mr. Shaw used no acid in the voltameter solution, a fact that will account for irregularities. Of these lines the heavy one was drawn as a fair average of them all. A glance at this line will derive some interesting results:

We see that with a current density of 50 square centimetres per ampère the ratio of silver to copper deposited is **3.401**. In the early part of Mr. Shaw's work, in a long series of observations, this same identical ratio as a mean for a mean current density the same as above was found.

Mr. Gray when at work on the same ratio determined the same identical value.

Finally the writer has found that if we take the values for the chemical equivalents for silver and copper as quoted by Wurtz and those given by Meyer that the calculated values for this ratio are 3.401 and 3.309 to 3.401.

Therefore, since we know with great assurance the value of the electro-chemical equivalent of silver, we have an equal assurance that with a *current density of one ampère for every 50 square centimetres exposed* the *amount of copper deposited* will be **.0003287** *grammes per coulomb*.

Again, we see that in a range of current density from 50 centimetres to 300 centimetres per ampère this line indicates a change in the amount of copper deposited from .0003287 to .0003270. It is to be remembered that these results were obtained by the use of a solution almost saturated and without acid. Returning to Mr. Gray's work we find that for the same range of current density the amount of copper deposit changes from .0003287 to .0003272 for a temperature at which Mr. Shaw probably worked.

It is well-known that the copper goes into solution under the action of the current from the cathode at much a greater rate with out acid than with, and especially at a greater rate when the solution is dense than when working under the proper conditions for measuring current. A comparison of Mr. Gray's and Mr. Shaw's results brought us to the belief that less copper should be dissolved from cathodes of the spiral coil form than those of the plate form.

To determine this four cells were arranged by Mr. Gunning, a student in the Sciences at Cornell. Two of these had cathodes and anodes of the plate form and the other two those of the "spiral coil" form. The large plate and coil and the small plate and coil had areas of 100 centimetres and 10 centimetres respectively. About half an ampère was passed through them for a time, amounting to two and one-half hours.

Every half hour they were taken out, dried and weighed, the solutions all intermixed, and the deposits continued for another half hour, etc.

The solution had a density of 1.1, and an addition of ¼ per cent. acid. An examination of the intermediate results gives the same result that one gets by looking at the total gain of the coils and plates taken separately. Mr. Gunning's results were as follows:

Temperature, 20 degrees.

Coils.		Plates.	
Small.	Large.	Small.	Large.
10 c.m.	100 c.m.	10 c.m.	100 c.m.
1.8220	1.8182	1.8196	1.8128

The result show that in going from a density of 20 centimetres to 200 centimetres per ampère, the amount of copper per coulomb changed from .0003289 to .0003283 for the coils, and for the plates, .0003285 to .0003275.

The result with the plates does not differ materially from that found by Mr. Gray for a similar range.

Mr. Gunning also made a number of comparisons of the spiral coil voltameter at different current densities, and at a mean temperature of 23 degrees centigrade, with the standard tangent galvanometer at the Magnetic Observatory. They were made with great care in every particular but one, and that was in the matter of time. This was taken from his own watch, that had not been compared with our standard chronometer. Again, to make and break the circuit, a large switch capable of carrying 250 ampères was operated, which added incidental errors, since the duration of each deposit was only 1,800 seconds; the results are interesting, because of their accordance and the manner in which they were obtained, and are given in the following table:

Date.	Size.	Current.	Gain in grammes.		Grammes per ampère per hour.
			Coil No. 1.	Coil No. 2.	
May 8 & 9.	110 c.m.	.6788	.3985	.3977	1.176
" "	" "	1.313	.7690	.7704	1.177
" "	" "	1.882	1.1060	1.1055	1.178
" "	" "	2.446	1.4364	1.4372	1.178
" 6 & 7.	110 "	3.008	1.7686	1.7676	1.179
" "	" "	3.532	2.0755	2.0753	1.179
" "	" "	4.016	2.3639	2.3639	1.180
" "	" "	4.495	2.6386	2.6326	1.176
" "	" "	4.930	2.8932	2.8910	1.176
" "	" "	5.263	3.0750	3.0808	1.173
" "	" "	5.701	3.3437	3.3453	1.176
" 8 & 9.	110 "	6.492	.....	3.7815	1.165*

* Deposit rough copper lost from both coils.

Fortenbaugh and West, also students in the laboratory, making use of a watch belonging to the former, known to the writer to have been keeping correct time, and otherwise precisely the same apparatus that Mr. Gunning used, obtained the following result:

Duration..... 40 m.
Current..... 1.314
Coil No. 1 gained..... 1.036 } Area,
" 2 " ..... 1.035 } 90 sq. c.m.

From this the number of grammes per ampère per hour is computed to be 1.182. And we know that for the above current density it should be 1.183. The galvanometer at the observatory is subject to a fluctuation in its indications by an amount that almost covers the above, due to variations of horizontal intensity throughout the succession of day and night.

The writer and Mr. E. G. Merritt, Fellow in Physics, Cornell University, hope to make a thorough investigation of the "Spiral Coil Voltameter" in its use with silver and copper shortly.

From the ease with which those inexperienced in the use of the copper voltameter obtain consistent results, it was thought well to recommend its use in the meantime to others.

Some Results With Secondary Batteries in Train Lighting.*

BY ALEXANDER S. BROWN.

The arguments in favor of the incandescent electric light for railway passenger trains are so well understood by the members of the Institute, from their own general knowledge of the subject, as well from papers previously presented, that it is unnecessary for me to allude to its admitted superiority over either gas, oil or candles. It is now four years since the Pennsylvania Railroad, appreciating the advantages of electric lighting for this purpose, began a series of experiments with the secondary battery, for the illumination of parlor cars.

I am unable to give the cost of lighting by any of the batteries referred to, as the expense appears to have been a secondary consideration compared with the necessity of securing the best system of illumination.

The first experiments made by the company were with the Faure accumulator, which was brought to this country from France in the spring or early summer of 1882, and put on passenger coach No. 397

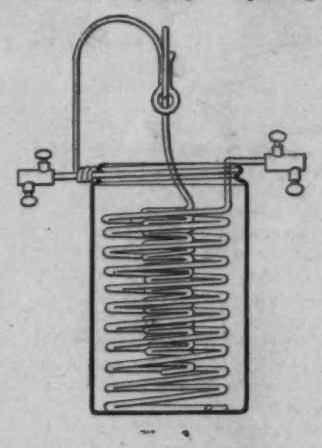


FIG. 2.—THE SPIRAL COIL VOLTAMETER.

in August of that year. The car was run for a few days only, but enough was learned in that time, to show that the lighting of cars by secondary batteries was perfectly practicable, when a modified form of the battery could be obtained.

During the summer of 1884, experiments with the Brush storage batteries were commenced at the Altoona shops of the Pennsylvania railroad, and continued through the fall and winter of that year. These experiments were made by Dr. Dudley, and proved so successful that eight parlor cars, which were being constructed at that time, were equipped for incandescent lighting and put into regular service on the 1st of April, 1885.

The Brush cells used consisted of three plates each, two negative and one positive, the amount of surface of the positive plate being equal to that of both the negatives. These plates differed from those now used, there being no paste in their composition. The negative plate herewith shows the form of construction, and was designed to give the greatest possible amount of surface from the least weight of material. The positive plate measured 8" x 9" x 1" and the negative 8" x 9" x ⅛".

These batteries are rated at 70 ampère hours, but the hard usage they received soon reduced their capacity, and at the end of a year's time the positive plates were almost entirely destroyed. In fact I have taken plates out of the cells which had holes in them fully four inches in diameter, while the deposit in the bottom of the cell would be from an inch to an inch and a half in depth. The plates also had a decided tendency both to buckle and grow, and in a number of cases it was a very difficult matter to remove the plates without injury to the cell; you will understand, of course

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*A paper read before the American Institute of Electrical Engineers, New York, May 22, 1889.
** *Phil. Mag.*, 1886 and 1888.
† *Lond. Elec. and Elec. Review*
‡ *N. Y. Elect'n*, October, 1888.

*Brit. Asso. Meeting, 1886. *N. Y. Elect'n*, 1887.

* A paper read before the American Institute of Electrical Engineers, New York, May 22, 1889.

that I allude more particularly to the positive plate. The weak points in the Brush battery were the small number of ampère hours per pound of material—about two I believe. There was a tendency to buckle and sulphate, and the arrangement for connecting the plates was such that there was oxidation at the junction, causing the plates to break when subject to the motion of the car. This last feature was a source of endless trouble to us, and as is usually the case, was sure to happen at a time or place where it was impossible to repair the break. While using the Brush battery the cars were wired with the battery boxes, one on each side of the car, coupled together in series, each box holding three trays, and each tray containing four cells, this giving a total of 24 cells to a car, or an E. M. F. of 48 volts. The lamps used originally were of the Brush-Swan type with small platinum loops projecting from the base, these hooking into a socket, and held in place by a spiral spring, this socket fitting into another one, to which the connections to the wires were made.

After using this style for some time an improved pattern of Brush-Swan lamp was substituted, but the great drawback to this lamp was its frailty, the breakage per day often averaging four per cent. of the total number of lamps in use on all the cars. These lamps required about 45 volts and 1 ampère of current, and each car contained 10 lamps, seven in the body, one in the smoking-room and one in each vestibule, thus using about 10 ampères of current, and as the batteries were rated at 70 ampère hours, we should have obtained from six and one-half to seven hours good light, but it was very seldom, after the batteries have been used for a short time, that we could get over five and one-half hours. As will readily be seen, this could hardly be called economical, for to obtain five or six hours' light we were obliged to charge from 15 to 20 hours with a Brush arc light dynamo giving a current of about 10 ampères. Then taking the weight into consideration, each time the car needed charging, the trays, six in number, and weighing 1,200 pounds, had to be loaded on the truck, pulled over to one side of the car, and the discharged trays taken out and the freshly charged ones put in their place. The remaining three were then taken around to the other side of the car and changed in the same manner. As the cars invariably stood on a double track it was necessary to carry half the trays for some distance, over tracks, etc. Then, again, the tracks were usually full of cars, and if there was not sufficient time for them to be parted the batteries had either to be carried under the car or over the platform. Under the present system this has been done away with to a great extent, as will be explained subsequently. During the month of December, 1886, we commenced using one battery of the 7 B type, manufactured by the Electrical Accumulator Company. This battery was a decided improvement over those previously used, giving as it did nearly double the number of ampère hours for the same weight of material. After using this battery for about a year the positive plate began to give way and new ones were substituted, the negatives, however, being retained, they not having deteriorated. In fact, we are still using the negative plates of our original 7 B battery. This battery proved to be so satisfactory that in June, 1887, we added two more of the same type and two manufactured by the Julien Electric Company. The latter batteries were similar in size and shape to the 7 B type of the Accumulator Company, but did not seem to stand the hard usage so well, as they would crack instead of buckling, and allow a large quantity of the paste to become loosened and fall out. It is proper to state, however, that these plates were made especially for us to fit the cells we were using, and were not of the regular Julien type. This, no doubt, will account in a great measure for their failure to keep up to the standard of the present type of Julien batteries. After the positive plates of this battery became worthless, and not having any others to put in their place, we decided to make a kind of consolidated affair and see how Julien negative and Accumulator positive plates, would work together. The result was extremely satisfactory, and we have had no trouble with them whatever, excepting the occasional buckling of a positive plate.

During the fall of 1887, we began substituting the accumulator batteries for the Brush batteries, and by the end of the year we were using them altogether, with the exception of the two Julien I have mentioned. We, however, kept 96 of our best Brush cells, to be used in case of an accident to the incandescent dynamos, which are used to supply the current for the railroad telegraph as well as for lighting the passenger station.

After the change in batteries had been made, it was thought best to change the system of wiring the cars, so that instead of its being necessary to put batteries on each side of the car, we need only put them on one side, and get the same amount of light. This was done by connecting the two boxes under the car in parallel, and substituting 23 volt Edison lamps for our 45 volt Brush-Swan lamps. After doing this we found that we were able to get as many hours light from 12 cells as we formerly did from 24. Of course this change reduced the expense of lighting the cars considerably, for where we formerly had a change of battery for each car, or 48 cells, we now needed only 24 cells per car, with a few extra ones to be used in case the 12 cells would not be able to supply sufficient light for a long trip. This system of lighting proved so successful that it was decided to substitute it for gas in the remaining seven parlor cars. The wiring of these cars was commenced at the Meadow shops, near Jersey City, last September, and has just been completed. These cars are arranged for the 23 C type of the Accumulator Company's battery, and 19 B type of the Julien battery. The battery boxes under the cars are larger than the old style and contain four trays or 16 cells, the lamps we used taking 23 volts E. M. F. Changes were also made the first of the year in the system of charging, and the batteries are now charged from an incandescent dynamo instead of an arc, thus enabling the batteries to be charged with any amount of current desired. In connection with this description of the four years' work of the Pennsylvania Railroad, I would like to add something in regard to the electric lighting of the Chicago limited express.

In 1887, the Pullman Palace Car Company commenced using the electric light on one of three trains of the New York and Chicago limited express, and the charging of the batteries at Jersey City was given into the hands of the Pennsylvania Railroad Company. The batteries used were the 7 B type of the Electrical Accumulator Co., 30 cells to a car, and usually there are six cars in the train. These batteries would furnish enough light for one trip, and each time the train arrived at either terminus it was necessary to replace them with freshly charged cells. This was not objectionable at Chicago, for the train arrived there in the morning, so that they could be charged during the day, but in Jersey City, where the train did not arrive until evening, the work was very difficult on account of the dynamo being in use for other purposes. After this one train had been running a short time, another one was fitted up, 19 B type of Julien battery being used. It was thought that this would give us a chance to see which was the better of the two batteries, but they both worked very well considering the treatment they received. After Mr. Bauer became connected with the Pullman Company, he did away with charging the batteries at the ends of the line, and introduced a Brotherhood engine and Eickemeyer dynamo in the baggage car of each train, in order that the batteries might be charged in transit. When the train leaves Jersey City, the baggage car is on the rear, and consequently no charging is done until it leaves Philadelphia, where the train is reversed, bringing the baggage car next to the locomotive. The batteries are charged continuously until the train reaches Chicago, and the same practice is continued on the return trip. The steam for driving the Brotherhood engine is taken from the locomotive boiler, and the exhaust is used for heating the train.

So far as the Pennsylvania Railroad is concerned the electric lighting of passenger trains may be considered an assured success, and leading as it does to the abolition of kerosene lamps, and incidentally encouraging the adoption of steam heating, the safety and comfort of the passenger is certainly increased.

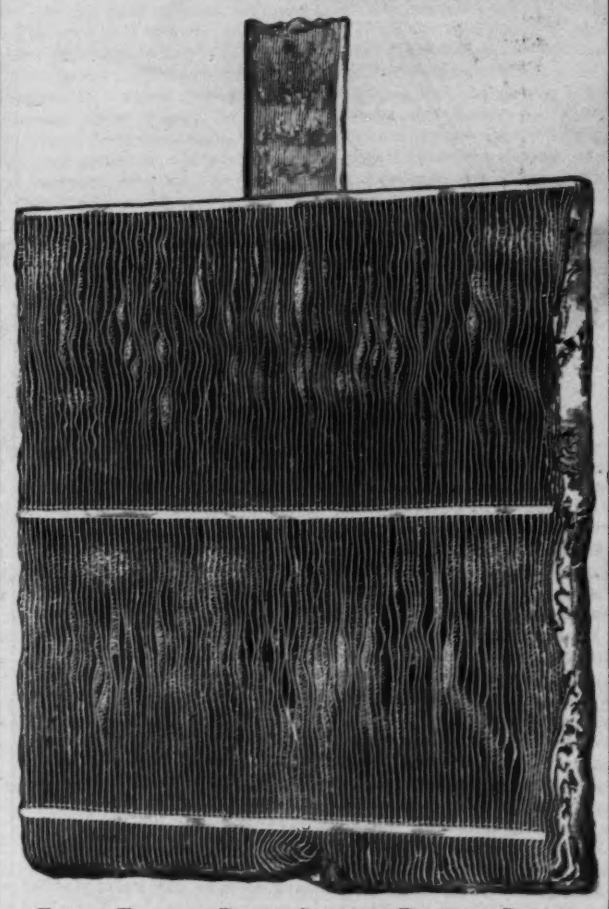
The Westinghouse vs. Edison Lamp Suit.

The suit of the Consolidated Electric Light Company vs. the McKeesport Light Company for the infringement of the Sawyer-Man lamp patent was begun in the United States Circuit Court at Pittsburgh on May 21. The suit is actually carried on by the Westinghouse Electric Company, as assignee of the Consolidated Company, and is defended by the Edison Electric Light Company, of which the McKeesport Light Company is a licensee.

The bench was occupied by Justice Bradley and Judges McKennan and Acheson. All kinds of electric appliances were arranged about the room. The Hon. John Dalzell opened the case for the Westinghouse side and traced the history of electric lighting by various forms of lamps up to the time when Sawyer and Man began their experiments, and he held that there was no successful lamp devised before that of Sawyer & Man.

Referring to the patent in suit, Mr. Dalzell argued that the improvements in the conductor itself form the gist of the invention, and the distinctive characteristics of these improvements are set forth in the first claim of the patent, which is for:

"An incandescing conductor for an electric lamp, of



EARLY FORM OF BRUSH STORAGE BATTERY PLATE.

carbonized fibrous or textile material, and of an arch or horseshoe shape, substantially as hereinbefore set forth."

In the body of the specification the patentees say:

"Our invention relates more especially to the incandescing conductor, its substance, its form, and its combination with the other elements composing the lamp."

With respect to the substance of the conductor, they describe it as "an incandescing conductor of carbon made from a vegetable fibrous material, in contradistinction to a similar conductor made from mineral or gas carbon." Further on they refer to the use of "carbonized paper and wood carbon," and they refer to "the manufacture of carbon from vegetable fibrous or textile material instead of mineral or gas carbon."

With respect to the form of the carbon, the patentees refer to the drawings, which show the carbon as having the form of an arch, and at the lines 75 to 86 of the first page, they refer to their having used carbons of various other shapes, and conclude by saying, "*but we prefer the arch shape.*" In the paragraph, commencing at line 100 of the first page, they refer to the advantages of the arch form in providing for the expansion and contraction of the carbon due to the great variations of temperature necessarily incident to the operation of the lamp, without altering the position of the fixed terminals, and thus obviating the necessity of using the mechanical devices which had been necessary for that purpose prior to their invention.

It thus clearly appeared that there were two distinctive peculiarities of the illuminating conductor referred to in the first claim which the patentees considered a part of their invention. First, that the conductor is to be made of carbonized fibrous or vegetable material in contradistinction to mineral or gas carbon.

The second feature of novelty of the first claim is that the conductor is to have the shape of an arch or horseshoe as distinguished from a straight strip or any other shape not performing the functions of the arch shape in providing for expansion and contraction.

Mr. Grosvenor P. Lowrey, of New York, opened the case in behalf of the Edison Company. His propositions in general were: That Mr. Edison began experimenting on the subject of electric light in 1877, prior to the professed invention of Sawyer & Man, and made use in his experiments of carbonized paper among numerous other things; that he subsequently conducted an extended series of experiments with platinum wire and other materials for conductors, that he was from the beginning convinced that carbon of some form, either fibrous or not, was the most desirable material for the incandescent conductor of an electric lamp, provided the lamp chamber could be so completely exhausted of air and so sealed and perfected as to maintain a stable vacuum that the carbon would be free from the attacks of oxygen, which destroy it when in a state of incandescence; that Edison was engaged, not in seeking a particular material for a lamp, but in seeking a lamp together with the other parts of an electric system which should enable electric lighting to be put on a common basis in respect to the cost of investment for conductors, etc.; that he finally achieved this in the fall of 1879 and exhibited his invention at Menlo Park, employing there a lamp which is substantially identical with that now in use by the plaintiff and all other companies using electric light; that the solution of the entire difficulty was the obtaining of the thread-like carbon, having high resistance to the passage of the electric current, secured in a glass chamber, sealed up by fusion of the glass, from which the air had been exhausted to the state of a high vacuum; that to accomplish this object he pursued the plan of high resistance in lamps and the employment of what is called the multiple arc; that in this respect his principles and methods were exactly opposite to those of Sawyer & Man, who sought for low resistance conductors, which were impracticable in the system of multiple arc, and would have caused, in a given instance named, a cost for street conductors of $30,000,000, whereas, by Edison's system, the same lighting facilities are afforded for about $200,000.

Mr. Edison finally selected bamboo fibre, which was the result of empirical experiments made by him at a cost of hundreds of thousands of dollars, by sending agents to different parts of the world to obtain wood which furnished the structure most favorable to producing this thread-like conductor, and possessing the high specific resistance of carbon. The original Sawyer-Man lamp was shown to nobody. The original Edison lamp was publicly exhibited at Menlo Park to thousands, and no claim was ever made that Sawyer & Man had invented such a lamp until after the publication in the New York papers of Dec. 21, 1879, of a full description, with illustrations of his lamp. As between Sawyer's written statement, made at the time, and Mr. Man's recollections, ten years old, the court must believe the former, to wit: That the Sawyer-Man fibrous carbon arch form lamp broke down from the first, and was not deemed by them worth the expenditure of $35 for a patent. This was published repeatedly by Mr. Sawyer in letters to the newspapers at the time, in which he declared that the Edison lamp would break down in the same way and was worthless. Their laboratory experiments covered six weeks from the opening.

Mr. R. N. Dyer, of New York, at the close of Mr. Lowrey's argument, took up the case for the defendant, and discussed in detail the technical features of the case. He showed that, beginning with the experiments of Sir Humphry Davy at the beginning of the century, the carbonized vegetable fibrous materials for incandescent lighting which are claimed to be monopolized by Sawyer & Man were in common use. The arch form, which is also claimed as a novel feature by the complainant, he also alleged to be old, both in metals and carbon, before Sawyer & Man claimed to have made their invention. Moreover, the patent is wholly insufficient in its description to enable a practical lamp to be made by it, and is therefore invalid at law. Mr. Dyer explained that the whole case of Sawyer & Man rests, by their own showing, on these words in their original specification: "We have tried carbonized paper covered with powdered plumbago."

Mr. Dyer argued that this description refers to an impracticable process, consisting of filling a strip of paper with powdered plumbago, and then passing the electric current through it.

The argument for the Westinghouse side was continued by Mr. Amos Broadnax, who contended that the one new thing in all the lamps was the fibrous conductor, and that was theirs. The Sawyer-Man lamp was perfected in March, 1878. Referring to the Sawyer letters, he said they were written when Sawyer was on a prolonged spree. Mr. Broadnax denied that Edison had used the fibrous conductor prior to 1878, and held that Edison's testimony showed that he had not used it until 1879.

Mr. Thurston made the closing argument for the Edison side. He gave a history of electricity and said that Edison in November, 1879, invented the hair-like fibrous conductor. The real contest, Mr. Thurston held, was whether the complainants have the exclusive use of all vegetable fibrous carbonized conductors.

Mr. Emanuel Wetmore, for Westinghouse, made the closing argument. He said that Mr. Edison had been credited with the invention of the entire incandescent electric system when it did not belong to him. He argued that the system first became practical after Sawyer and Man discovered the suitable fibre. The statement that the Sawyer-Man lamp would not work was incorrect. It had been fully tested and found to burn for 150 hours. It was not necessary that it should have a high vacuum. He denied that bamboo fibre was the only available material for the carbons. He said that the Edison Company, with all its vast wealth, had no right to take the Sawyer-Man material and then contemptuously deny that they were infringing on the discovery. Both sides submitted their briefs, and the case was left with the Judges.

Mr. Wiman at the New York Electric Club.

At the meeting of the New York Electric Club, on May 23, Mr. Erastus Wiman gave an address on "Electrical Possibilities as Viewed by a Business Man." He said that he had a more thorough knowledge of base ball than electricity, viewed from a scientific standpoint. Viewed from a business standpoint, he advised the electrical companies to combine and form a syndicate, like the Standard Oil, rather than spend their time in the courts.

"I went into a bank the other day to get a little money," continued Mr. Wiman, "and they asked me for my securities. I offered electrical securities, and they were refused. 'They are no good,' said the president. 'The patents are all wrong, and there is such strong competition, and moreover you can never tell when another new Mayor is coming along with an axe to cut down you

poles.' Competition has been described as the life of trade, but it is the death of profit, and in no business is there stronger competition than in the electrical. If the companies were properly consolidated these electrical securities would be the best kind of investments. Competitive telegraphy is not a success." The address was delivered with all Mr. Wiman's characteristic eloquence and humor, and was well received by a large gathering.

On Modern Views with Respect to the Nature of Electric Currents.*

BY PROF. H. A. ROWLAND.

As, a short time since, I stood in a library of physical books and glanced around me at the works of the great masters in that subject, my mind wandered back to the time when the apparatus for a complete course of lectures on the subject of electricity consisted of a piece of amber and a few light bodies to be attracted by it. From that time until now, when we stand in a magnificent laboratory with elaborate and costly apparatus in great part devoted to its study, how greatly has the world changed and how our science of electricity has expanded both in theory and practice until, in the one case, it threatens to include within itself nearly the whole of physics, and in the other to make this the age of electricity.

Were I to trace the history of the views of physicists with respect to electric currents it would include the whole history of electricity. The date when the conception of an electric current was possible was that when Stephen Gray, about 170 years ago, first divided bodies into conductors and non-conductors, and showed that the first possessed the property of transmitting electric attractions to a distance. But it was only when the Leyden jar was discovered that the idea of a current became very definite. The notion that electricity was a subtle fluid which could flow along metal wires as water flows along a tube, was then prevalent, and, indeed, remains in force to-day among all except the leaders in scientific thought. It is not my intention to depreciate this notion, which has served and still serves a very important purpose in science. But, for many years, it has been recognized that it includes only a very small portion of the truth and that the mechanism by which energy is transmitted from one point of space to another by means of an electric current is a very complicated one.

Here, for instance, on the table before me are two rubber tubes filled with water, in one of which the water is in motion and the other at rest. It is impossible by any means now known to us, to find out, without moving the tubes, which one has the current of water flowing in it and which has the water at rest. Again, I have here two wires, alike in all respects, except that one has a current of electricity flowing in it and the other has not. But in this case, I have only to bring a magnetic needle near the two to find out in which one the current is flowing. On our ordinary senses the passage of the current has little effect; the air around it does not turn green or the wire change in appearance. But we have only to change our medium from air to one containing magnetic particles to perceive the commotion which the presence of a current may cause. Thus this other wire passes through the air near a large number of small suspended magnets, and, as I pass the current through it, every magnet is affected and tends to turn at right angles to the wire and even to move toward it and wrap itself around it. If we suppose the number of these magnets to become very great and their size small, or if we imagine a medium, every atom of which is a magnet, we see that no wire carrying a current of electricity can pass through it without creating the greatest commotion. Possibly this is a feeble picture of what takes place in a mass of iron near an electric current.

Again, coil the wire around a piece of glass, or, indeed, almost any transparent substance, and pass a strong current through the wire. With our naked eye alone we see no effect whatever, as the glass is apparently unaltered by the presence of the current, but, examined in the proper way by means of polarized light, we see that the structure of the glass has been altered throughout in a manner which can only be explained by the rotation of something within the glass many millions of times every second.

Once more, bring a wire in which no current exists nearer and nearer to the one carrying the current, and we shall find that its motion in such a neighborhood causes, or tends to cause, an electric current in it. Or, if we move a large solid mass of metal in the neighborhood of such a current we find a peculiar resistance unfelt before, and if we force it into motion we shall perceive that it becomes warmer and warmer as if there was great friction in moving the metal through space.

Thus, by these tests, we find that the region around an electric current has very peculiar properties which it did not have before, and which, although stronger in the neighborhood of the current, still extend to indefinite distances in all directions, becoming weaker as the distances increase.

How great, then, the difference between a current of water and a current of electricity. The action of the former is confined to the interior of the tube, while that of the latter extends to great distances on all sides, the whole of space being agitated by the formation of an electric current in any part. To show this agitation, I have here two large frames with coils of wire around them. They hang face to face about 6 feet apart. Through one I discharge this Leyden jar, and immediately you see a spark at a break in the wire of the other coil, and yet there is no apparent connection between the two. I can carry the coils 50 feet or more apart, and yet, by suitable means, I can observe the disturbances due to the current in the first coil.

The question is forced upon us as to how this action takes place. How is it possible to transmit so much power to such a distance across apparently unoccupied space? According to our modern theories of physics there must be some medium engaged in this transmission. We know that it is not the air, because the same effects take place in a vacuum, and, therefore, we must fall back on that medium which transmits light and which we have named the ether. That medium which is supposed to extend unaltered throughout the whole of space, whose existence is very certain but whose properties we have yet but vaguely conceived.

I cannot, in the course of one short hour, give even an idea of the process by which the minds of physicists have been led to this conclusion, or the means by which we have finally completely identified the ether which transmits light with the medium which transmits electrical and magnetic disturbances. The great genius who first identified the two is Maxwell, whose electro-magnetic theory of light is the centre around which much scientific thought is to-day revolving, and which we regard as one of the greatest steps by which we advance nearer to the understanding of matter and its laws. It is this great discovery of Maxwell which allows me, at the present time, to attempt to explain to you the wonderful events which happen everywhere in space when one establishes an electric current in any other portion.

In the first place, we discover that the disturbance does not take place in all portions of space at once, but proceeds outwards from the centre of the disturbance with a velocity exactly equal to the velocity of light. So that, when I touch these wires together so as to complete the circuit of yonder battery, I start a wave of etherial

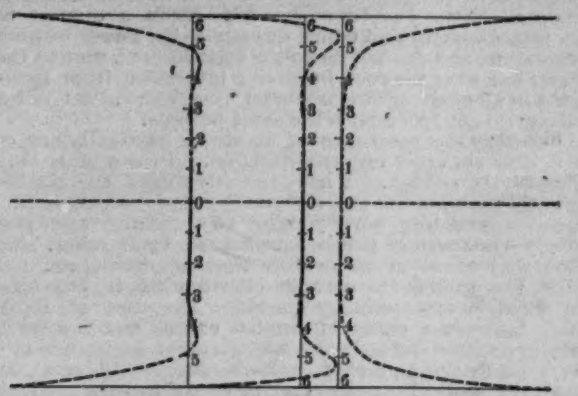


FIG. 1.—PENETRATION OF ALTERNATING CURRENT IN A ROUND SOLID CONDUCTOR.

disturbance which passes outward with a velocity of 185,000 miles per second, thus reaching the sun in about eight minutes, and continuing to pass outwards forever or until it reaches the bounds of the universe. And yet none of our senses inform us of what has taken place unless we sharpen them by the use of suitable instruments. Thus, in the case of these two coils of wire, suspended near each other, which we have already used, when the wave from the primary disturbance reaches the second coil, we perceive the disturbance by means of the spark formed at the break in the coil. Should I move the coils further apart, the spark in the second coil would be somewhat delayed, but the distance of 185,000 miles would be necessary before this delay could amount to as much as one second. Hence the effects we observe on the earth take place so nearly instantaneously that the interval of time is very difficult to measure, amounting, in the present case, to only $\frac{1}{1000000}$th of a second.

It is impossible for me to prove the existence of this interval, but I can at least show you that waves have something to do with the action here observed. For instance, I have here two tuning forks mounted on sounding boxes and tuned to exact unison. I sound one and then stop its vibrations with my hand; instantly you hear that the other is in vibration, caused by the waves of sound in the air between the two. When, however, I destroy the unison by fixing this piece of wax on one of the forks the action ceases.

Now, this combination of a coil of wire and a Leyden jar form a vibrating system for electricity and its time of vibration is about 10,000,000 times a second. This second sys-

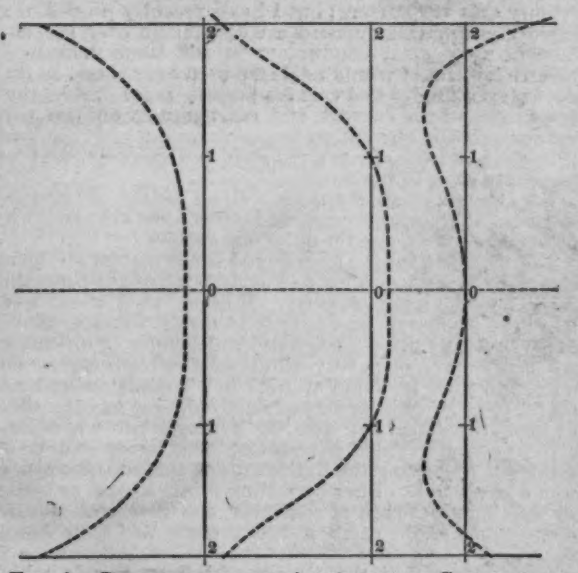


FIG. 2.—PENETRATION OF ALTERNATING CURRENT IN A ROUND SOLID CONDUCTOR.

tem is the same as the first, and therefore its time of vibration is the same. You see how well the experiment works now because the two are in unison. But let me take away this second Leyden jar, thus destroying the unison, and you see that the sparks instantly cease. Replacing it, the sparks reappear. Adding another on one side and they disappear again, only to reappear when the system is made symmetrical by placing two on each side.

This experiment and that of the tuning forks have an exact analogy to one another. In each we have two vibrating systems connected by a medium capable of transmitting vibrations, and they both come under the head of what we know as sympathetic vibrations. In the one case, we have two mechanical tuning forks connected by the air; in the other, two pieces of apparatus, which we might call electrical tuning forks, connected by the luminiferous ether. The vibrations in one case can be seen by the eye or heard by the ear, but in the other case they can only be perceived when we destroy them by making them produce a spark. The fact that we are able to increase the effect by proper tuning demonstrates that vibrations are concerned in the phenomenon. This can, however, be separately demonstrated by examining the spark by means of a revolving mirror, when we find that it is made up of many successive sparks corresponding to the successive backward and forward movements of the current.

The fact of the oscillatory character of the Leyden jar discharge was first demonstrated by our own countryman, Henry, in 1832, but he pursued the subject only a short distance, and it remained for Sir William Thomson to give the mathematical theory and prove the laws according to which the phenomenon takes place.

Thus, in the case of a charged Leyden jar whose inner and outer coatings have been suddenly joined by a wire, the electricity flows back and forth along the wire until all the energy originally stored up in the jar has expended itself in heating the wire or the air where the spark takes place and in generating waves of disturbance in the ether which move outward into space with the velocity of light. These etherial waves we have demonstrated by letting them fall on this coil of wire and causing the electrical disturbance to manifest itself by electric sparks.

I have here another more powerful arrangement for producing electro-magnetic waves of very long wave length, each one being about 500 miles long. It consists of a coil within which is a bundle of iron wires. On passing a powerful alternating current through the coil, the iron wires are rapidly magnetized and demagnetized, and send forth into space a system of electro-magnetic waves at the rate of 360 in a second.

Here, also, I have another piece of apparatus for sending out the same kind of electro-magnetic waves, and, on applying a match, we start it also into action.* But the last apparatus is tuned to so high a pitch that the waves are only $\frac{1}{55000}$ inch long, and 55,000,000,000,000 are given out in one second. These short waves are known by the name of light and radiant heat, though the name radiation is more exact. Placing any body near the lamp so that the radiation can fall on it, we observe that when the body absorbs the rays it is heated by them; the well-known property of so-called radiant heat and light. Is it not possible for us to get some substance to absorb the long waves of disturbance, and so obtain a heating effect? I have here such a substance in the shape of a sheet of copper, which I fasten on the face of a thermopile, and I hold it where these waves are the strongest. As I have anticipated, great heat is generated by their absorption, and soon the plate of copper becomes very warm, as we see by this thermometer, by feeling of it with the hand or even by the steam from water thrown upon it. In this experiment the copper has not touched the coil or the iron wire core, although if it did they are very much cooler than itself. The heat has been produced by the absorption of the waves in the same way as a blackened body absorbs the rays of shorter wave length from the lamp; and, in both cases, heat is the result.

But in this experiment, as in the first one, the wave-like nature of the disturbance has not been proved experimentally. We have caused electric sparks, and have heated the copper plate across an interval of space, but have not in either of these cases proved experimentally the progressive nature of the disturbance.

A ready means of experimenting on the waves, obtaining their wave length and showing their interferences, has hitherto been wanting. This deficiency has been recently overcome by Professor Hertz, of Carlsruhe, who has made a study of the action of the coil, and has shown us how to use it for experiments on the etherial waves whose existence had before been made certain by the mathematics of Maxwell.

I scarcely know how to present this subject to a non-technical audience and make it clear how a coil of wire with a break in it can be used to measure the velocity and wave length of etherial waves. However, I can but try. If the waves moved very slowly, we could readily measure the time the first coil took to affect the second, and show that this time was longer as the distance was greater. But it is absolutely inappreciable by any of our instruments, and another method must be found. To obtain the wave length, Professor Hertz used several methods, but that by the formation of stationary waves is the most easily grasped. Mr. Ames holds in his hand one end of a spiral spring, which makes a very heavy and flexible rope. As he sends a wave down it, you see that it is reflected at the further end, and returns again to his hand. If, however, he send a succession of waves down the rope, the reflected waves interfere with the direct ones, and divide the rope into a succession of nodes and loops, which you now observe. So a series of sound waves, striking on a wall, form a system of stationary waves in front of the wall. Indeed, we can use any waves for this purpose, even etherial waves. With this in view Professor Hertz established his apparatus in front of a reflecting wall, and observed the nodes and loops by the sparks produced in a ring of wire, somewhat resembling the coil I have been using on the present occasion but much smaller. It is impossible for me to repeat this experiment before you, as it is a very delicate one, and the sparks produced are almost microscopic. Indeed, I should have to erect an entirely different apparatus, as the waves from the one before me are nearly ¼ mile long, the time of vibration of the system being very great, that is, $\frac{1}{10000000}$th of a second. To produce shorter waves, we must use apparatus tuned, as it were, to a higher pitch, in which the same principle is, however, employed, but the etherial waves are shorter, and thus several stationary waves can be contained in one room.

The testing coil is then moved to different portions of the room, and the nodes are indicated by the disappearance of the sparks, and the loops by the greater brightness of them. The presence of stationary waves is thus proved, and their half waves length found from the distance from node to node, for stationary waves can always be considered as produced by the interference of two progressive waves advancing in opposite directions.

However interesting a further description of Professor Hertz's experiments may be, we have gone as far in that direction as our subject carries us, for we have demonstrated that the production of a current in a wire is accompanied by a disturbance in the surrounding space; and although I have not experimentally demonstrated the etherial waves, yet I have proved the existence of electric oscillations in the coils of wire and the ether surrounding it.

Our mathematics has demonstrated, and experiments like those of Professor Hertz have confirmed the demonstration, that the wave disturbance in the ether is an actual fact.

The closing of a battery circuit, then, and the establishment of a current of electricity in a wire, is a very different process from the formation of a current of water

* A lecture given at the College of the City of New York, May 22, 1889, before the American Institute of Electrical Engineers.

* The lecturer here lit a gas flame.

in a pipe, though, after the first shock, the laws of the flow of the two are very much alike. But even then the medium around the current of electricity has very strange properties, showing that it is accompanied by a disturbance throughout space. The wire is but the core of the disturbance, which latter extends indefinitely in all directions.

One of the strangest things about it is that we can calculate with perfect exactness the velocity of the wave propagation and the amount of the disturbance at every point and at any instant of time; but as yet we cannot conceive of the details of the mechanism which is concerned in the propagation of an electric current. In this respect our subject resembles all other branches of physics in the partial knowledge we have of it. We know that light is the undulation of the luminiferous ether, and yet the constitution of the latter is unknown. We know that the atoms of matter can vibrate with purer tones than the most perfect piano, and yet we cannot even conceive of their constitution. We know that the sun attracts the planets with a force whose law is known, and yet we fail to picture to ourselves the process by which it takes our earth within its grasp at the distance of many millions of miles and prevents it from departing forever from its life-giving rays. Science is full of this half knowledge, and the proper attitude of the mind is one of resignation toward that which it is impossible for us to know at present and of earnest striving to help in the advance of our science, which shall finally allow us to answer all these questions.

The electric current is an unsolved mystery, but we have made a very great advance in understanding it when we know that we must look outside of the wire at the disturbance in the medium before we can understand it—a view which Faraday dimly held fifty years ago, which was given in detail in the great work of Maxwell, published sixteen years since, and has been the guide to most of the work done in electricity for a very long time.—a view which has wrought the greatest changes in the idea which we have conceived with respect to all electrical phenomena.

So far we have considered the case of alternating electric current in a wire connecting the inner and outer coatings of a Leyden jar. The invention of the telephone, by which sound is carried from one point to another by means of electrical waves, has forced into prominence the subject of these waves. Furthermore, the use of alternating currents for electric lighting brings into play the same phenomenon. Here, again, the difference between a current of water and a current of electricity is very marked. A sound wave, traversing the water in the tube, produces a to and fro current of water at any given point. So, in the electrical vibration along a wire, the electricity moves to and fro along it in a manner somewhat similar to the water, but with this difference. The disturbance from the water motion is confined to the tube, and the oscillation of the water is greatest in the centre of the tube, while, in the case of the electric current, the ether around the wire is disturbed and the oscillation of the current is greatest at the surface of the wire and least in its centre. The oscillations in the water take place in the tube without reference to the matter outside the tube, whereas the electric oscillations in the wire are entirely dependent on the surrounding space, and the velocity of the propagation is nearly independent of the nature of the wire, provided only that it is a good conductor.

We have then in the case of electrical waves along a wire, a disturbance outside the wire and a current within it, and the equations of Maxwell allow us to calculate these with perfect accuracy and give all the laws with respect to them.

We thus find that the velocity of propagation of the waves along a wire, hung far away from other bodies and made of good conducting material, is that of light, or 185,000 miles per second, but when it is hung near any conducting matter, like the earth, or inclosed in a cable and sunk into the sea, the velocity becomes much less. When hung in space, away from other bodies, it forms, as it were, the core of a system of waves in the ether, the amplitude of the disturbance becoming less and less as we move away from the wire. But the most curious fact is that the electric current penetrates only a short distance into the wire, being mostly confined to the surface, especially where the number of oscillations per second is very great.

The electrical waves at the surface of a conductor are thus, in some respects, very similar to the waves on the surface of water. The greatest motion in the latter case is at the surface while it diminishes as we pass downward and soon becomes inappreciable. Furthermore, the depth to which the disturbance penetrates into the water increases with increase of the length of the wave, being confined to very near the surface for very short waves. So the disturbance in the copper penetrates deeper as the waves and the time of oscillation are longer, and the disturbance is more nearly confined to the surface as the waves become shorter. I have recently made the complete calculation with respect to these waves, and have drawn some diagrams to illustrate the penetration of the alternating current into metal cylinders. The right-hand curve, Fig. 1, represents the current at different depths in a copper cylinder 45 cm. diameter, or an iron one 14½ cm. diameter, traversed by an alternating current with 200 reversals per second. That and the middle curve show us the current at two different instants of time, and show us how the phase changes as we pass downward into the cylinder. By reference to the middle curve we see that it may be even in the opposite direction in the centre of the cylinder from which it is at the surface. The third figure gives us the amplitude of the current oscillations at different depths, irrespective of the phase, and it shows us that the current at the centre is only about 10 per cent. of that at the surface in this case. The second diagram Fig. 2 shows us the distribution in the same cylinders when the number of reversals of the current is increased to 1,800 per second. Here we see that the disturbance is almost entirely confined to the surface, for at a depth of only 7 mm., the disturbance almost entirely vanishes.

There are very many practical applications of these theoretical results for electric currents. The most obvious one is to the case of conductors for the alternating currents used in producing the electric light. We find that when these are larger than about half an inch diameter they should be replaced by a number of conductors less than half an inch diameter, or by strips about quarter of an inch thick, and of any convenient width. But this is a matter to be attended to by the electric light companies.

Prof. Oliver J. Lodge has recently, in the B. A., drawn attention to another application of these results, that is, to lightning rods. Almost since the time of Franklin, there have been those who advocated the making of lightning rods hollow in order to increase the surface for a given amount of copper. We now know that these persons had no reason for their belief, as they simply drew the inference from the fact that electricity at best is on the surface. Neither were the advocates of the solid rods quite correct, for they reasoned from the fact that electricity in a state of steady flow occupies the whole area of the conductor equally. The true theory, we now know, indicates that neither party was entirely correct and that the surface is a very important factor in the case of a current of electricity so sudden as that from a lightning discharge. But increase of surface can best be obtained by multiplying the number of conductors, rather than making them flat or hollow, and, at the same time, Maxwell's principle of inclosing the building within a cage can be carried out. Theory indicates that the current penetrates only one-tenth the distance into iron that it does into copper. As the iron has seven times the resistance of copper, we should need 70 times the surface of iron that we should of copper. Hence I prefer copper wire about a quarter of an inch diameter and nailed directly to the house without insulators, and passing down the four corners, around the eaves and over the roof, for giving protection from lightning in all cases where a metal roof and metal down spouts do not accomplish the same purpose.

Whether the discharge of lightning is oscillatory or not, does not enter into the question, provided it is only sufficiently sudden. I have recently solved the mathematical problem of the electric oscillations along a perfectly conducting wire joining two infinite and perfectly conducting planes parallel to each other, and find that there is no definite time of oscillation, but that the system is capable of vibrating in any time in which it is originally started. The case of lightning between a cloud of limited extent and the earth along a path through the air of great resistance is a very different problem. Both the cloud and the path of the electricity are poor conductors, which tends to lengthen the time. If I were called on to estimate as nearly as possible what took place in a flash of lightning, I would say that I did not believe that the discharge was always oscillating, but more often consisted of one or more streams of electricity at intervals of a small fraction of a second, each one continuing for not less than $\frac{1}{100000}$ second. An oscillating current with 100,000 reversals per second would penetrate about $\frac{1}{10}$ inch into copper and $\frac{1}{30}$ inch into iron. The depth for copper would constitute a considerable proportion of a wire $\frac{1}{2}$ inch diameter, and, as there are other considerations to be taken into account, I believe it is scarcely worth while making tubes, or flat strips, for such small sizes.

It is almost impossible to draw proper conclusions from experiments on this subject in the laboratory, such as those of Prof. Oliver J. Lodge. The time of oscillation of the current in most pieces of laboratory apparatus is so very small, being often the $\frac{1}{1000000000}$th of a second, that entirely wrong inferences may be drawn from them. As the size of the apparatus increases the time of oscillation increases in the same proportion, and changes the whole aspect of the case. I have given $\frac{1}{100000}$th of a second as the shortest time a lightning flash could probably occupy. I strongly suspect it is often much greater, and thus departs even further from the laboratory experiments of Professor Lodge, who has, however, done very much toward drawing attention to this matter and showing the importance of surface in this case. All shapes of the rod with equal surface are not, however, equally efficient. Thus, the inside surface of a tube does not count at all. Neither do the corrugations on a rod count for the full value of the surface they expose, for the current is not distributed uniformly over the surface; but I have recently proved that rapidly alternating currents are distributed over the surface of very good conductors in the same manner as electricity at rest would be distributed over them, so that the exterior angles and corners possess much more than their share of the current, and corrugations on the wire concentrate the current on the outer angles and diminish it in the hollows. Even a flat strip has more current on the edges than in the centre.

For these reasons, shape, as well as extent of surface, must be taken into account, and strips have not always an advantage over wires for quick discharges.

The fact that the lightning rod is not melted on being struck by lightning is not now considered as any proof that it has done its work properly. It must, as it were, seize upon the discharge, and offer it an easier passage to the earth than any other. Such sudden currents of electricity we have seen to obey very different laws from continuous ones, and their tendency to stick to a conductor and not fly off to other objects depends not only on having them of small resistance but also on having what we call the self-induction as small as possible. This latter can be diminished by having the lightning rod spread sideways as much as possible, either by rolling it into strips, or better, by making a network of rods over the roof with several connections to the earth at the corners, as I have before described.

Thus we see that the theory of lightning rods, which appeared so simple in the time of Franklin, is to-day a very complicated one and requires for its solution a very complete knowledge of the dynamics of electric currents. In the light of our present knowledge the frequent failure of the old system of rods is no mystery, for I doubt if there are a hundred buildings in the country properly protected from lightning. With our modern advances, perfect protection might be guaranteed in all cases, if expense were no object.

So much for the rod itself, and now let us turn to other portions of the electrical system, for we have seen that, in any case, the conductor is only the core of a disturbance which extends to great distances on all sides. Were the clouds, the earth and the streak of heated air called the lightning flash all perfect conductors we could calculate the entire disturbance. It might then consist of a series of stationary waves between the two planes, extending indefinitely on all sides, but with gradually decreasing amplitude as we pass away from the centre. The oscillation, once set up, would go on forever, as there would be no poor conductors to damp them. But when the clouds and the path of the lightning both have very great resistance, the energy is very soon converted into heat and the oscillations destroyed. I have given it as my opinion that this is generally the case, and that the oscillations seldom take place, but I may be wrong, as there is little to guide me except guess work. If they take place, however, we have a ready explanation of what is sometimes called a back stroke of lightning. That is, a man at the other end of the cloud a mile or more distant from the lightning stroke sometimes receives a shock, or a new lightning flash may form at that point and kill him. This may be caused, according to our present theory, by the arrival of the waves of electrical disturbance which might themselves cause a slight shock or even overturn the equilibrium then existing and cause a new electric discharge.

We have now considered the case of oscillations of electricity in a few cases, and can turn to that of steady currents. The closing of an electric current sends etherial waves throughout space, but that after the first shock the current flows steadily without producing any more waves. However, the properties of the space around the wire have been permanently altered, as we have already seen. Let us now study these properties more in detail. I have before me a wire in which I can produce a powerful current of electricity, and we have seen that the space around it has been so altered that a delicately suspended magnetic needle cannot remain quiet in all positions, but stretches itself at right angles to the wire, the north pole tending to revolve around it in one direction and the south pole in the other. This is a very old experiment, but we now regard it as evidence that the properties of the space around the wire have been altered rather than that the wire acts on the magnet from a distance.

Put, now, a plate of glass around the wire, the latter being vertical and the former with its plane horizontal, and pass a powerful current through the wire. On now sprinkling iron filings on the plate they arrange themselves in circles around the wire and thus point out to us the celebrated lines of magnetic force of Faraday. Using two wires with currents in the same direction we get these other curves, and, testing the forces acting on the wire, we find that they are trying to move toward each other.

Again, pass the currents in the opposite directions and we get these other curves and the currents repel each other. If we assume that the lines of force are like rubber bands which tend to shorten in the direction of their length and repel each other sideways, Faraday and Maxwell have shown that all magnetic attraction and repulsions are explained. The property which the presence of the electric current has conferred on the luminiferous ether is then one by which it tends to shorten in one direction and spread out in the other two directions.

We have thus done away with action at a distance, and have accounted for magnetic attraction by a change in the intervening medium as Faraday partly did almost fifty years ago. For this change in the surrounding medium is as much a part of the electric current as anything that goes on within the wire.

To illustrate this tension along the lines of force, I have constructed this model, which represents the section of a coil of wire with a bar of iron within it. The rubber bands represent the lines of force which pass around the coil and through the iron bar, as they have an easier passage through the iron than the air. As we draw the bar down and let it go, you see that it is drawn upward and oscillates around its position of equilibrium until friction brings it to rest. Here, again, I have a coil of wire with an iron bar within it with one end resting on the floor. As we pass the current and the lines of magnetic force form around the coil and pass through the iron, it is lifted upwards although it weighs 24 pounds and oscillates around its position of equilibrium exactly the same as though it were sustained by rubber bands as in the model. The rubber bands in this case are invisible to our eye, but our mental vision pictures them to us as lines of magnetic force in the luminiferous ether drawing the bar upward by their contractile force. This contractile force is no small quantity, as it may amount, in some cases, to one or even two hundred pounds to the square inch, and thus rivals the greatest pressure which we use in our steam engines.

Thus the luminiferous ether is, to-day, a much more important factor in science than the air we breathe. We are constantly surrounded by the two, and the presence of the air is manifest to us all; we feel it, we hear by its aid, and we even see it, under favorable circumstances, and the velocity of its motion as well as the amount of moisture it carries is a constant topic of conversation with mankind at large. The luminiferous ether, on the other hand, eludes all our senses, and it is only with imagination, the eye of the mind, that its presence can be perceived. By its aid in conveying the vibrations we call light, we are enabled to see the world around us, and by its other motions which cause magnetism, the mariner steers his ship through the darkest night when the heavenly bodies are hid from view. When we speak in a telephone, the vibrations of the voice are carried forward to the distant point by waves in the luminiferous ether, there again to be resolved into the sound waves of the air. When we use the electric light to illuminate our streets, it is the luminiferous ether which conveys the energy along the wires as well as transmits it to our eye after it has assumed the form of light. We step upon an electric street car and feel it driven forward with the power of many horses, and again it is the luminiferous ether, whose immense force we have brought under our control and made to serve our purpose. No longer a feeble uncertain sort of medium, but a mighty power, extending throughout all space and binding the whole universe together, so that it becomes a living unit in which no one portion can be changed without ultimately involving every other portion.

To this, ladies and gentlemen, we have been led by the study of electrical phenomena, and the ideas which I have set forth constitute the most modern views held by physicists with respect to electric currents.

A Sprague Electric Railway for Pittsburgh.

We understand that the Sprague Electric Railway and Motor Company has recently closed a very important contract for electric railway apparatus at Pittsburgh, Pa., calling for twenty five cars with complete station equipment and overhead line system. The contracting street railway company is the Federal Street & Pleasant Valley Railroad Company, the largest and most important railway company in Pittsburgh and Allegheny City, Pa., and it is said that this equipment is only the first part of a very large order for electric railway cars. Before deciding which electric system to use in Pittsburgh, the president of the road, Mr. William McCreery, and a number of the directors made a careful and thorough ex-

amination of all the systems of electric railways in use in different parts of the country, and carefully examined into the workings of the different systems. During this investigation, the committee in charge visited a large number of cities in which there are electric railways in operation, including Atlantic City, N. J., where the cars there using the latest type of Sprague motors were shown. The committee expressed themselves as being very much pleased with the new motors at Atlantic City, their ease in starting and stopping, and the ability of the cars to speed up and to round the curves.

The road at Pittsburgh will run through the most important streets of the city, and the overhead work will be of the lightest description. Iron poles will be used for a great portion of the distance, and every device and improvement for increasing the sightliness and good service of the cars has been ordered for Pittsburgh. There will soon be no horse cars left in Pittsburgh.

The Kind of Dynamo the Schuyler Electric Company Have.

To the Editor of The Electrical World:

SIR: Our attention has been called to an article in your issue of May 25 by H. F. Watts, which states that what is wanted is a dynamo with an armature that is fire proof or that will not burn out, and that this has not yet been produced. The gentleman is evidently not familiar with the Schuyler dynamo, or he would not have made this latter statement.

We flatter ourselves, and we think with reason, that we have and are producing armatures that are proof against a burn out. At all events, we have so much confidence in them that we are willing to warrant them. An experience of between three and four years with our improved ventilated form gives us this assurance, and we have yet to learn of a burn out in this style of armature.

SCHUYLER ELECTRIC COMPANY,
MIDDLETOWN, Conn. J. T. Elliott, Treas.

Special Correspondence.

NEW YORK NOTES.

OFFICE OF THE ELECTRICAL WORLD,
167-177 TIMES BUILDING, NEW YORK, May 27, 1889.

The Magneto-Electric Machine Company, Limited, have taken an office at room 24, 102 Chambers street.

The American Electrical Construction Company, Mr. Henry Irvine, president, and Mr. Grimwood, vice-president, are to be found at 115 Broadway, where they have a large amount of business in hand and to come.

The Racine Oil Engine is on exhibition at the offices of the Hartford Dynamic Company, 74-76 Cortlandt street, corner of Washington. The engine is of 3 h. p., and Mr. Long states that they will soon have a fine nickel 1 h. p. engine on exhibition alongside the handsome Continental dynamo now placed in their window.

Mr. E. M. Brown, of 983 Lexington avenue, has fitted up one of the Long Island Sound steamers, with a projector using the arc light, which is placed over the pilot house, and is said to throw a strong beam of light through a dense fog for about three-quarters of a mile. The Kinsman arc lamp was used. Mr. Brown expects to fit out all the Sound steamers in a similar manner.

Mr. R. T. Macdonald, of the Fort Wayne Jenney Company, has been in town all the week, looking none the worse for the severe accident which he met with when the local papers described him, in large type, as being "hit with a brick." Mr. Macdonald has all his wonted energy, and says that he hopes to have the new factory thoroughly going in a short time. In the meantime he is very much annoyed at having to inform numerous applicants for plant that they must be patient. The New York offices have removed to the second floor of 115 Broadway, where they have much greater conveniences. Mr. H. C. Adams continues as New York manager.

Mr. M. E. Baird, of the Eddy Electric Company, was in New York last week and reports an active demand for the Eddy motor. He has recently sold thirteen motors, running from ¼ to 5 h. p., for use at Newark, N. J., where they are going on the United States circuits. At Kansas City they are doing a large business, as an instance of which I may mention that five 7½ h. p., three 2 h. p. and one 16 h. p. were put in in three weeks. In Detroit the motors are doing well, and one large factory has been equipped with them from top to bottom. Down South, also, there is a good market, and it is likely that before long a very large number will be in operation in New Orleans, where the motors are greatly liked.

Mr. Harold P. Brown, whom his friends and enemies describe as "the well known, the notorious, the infamous," etc., has, it may be mentioned, his offices with the Safety Electric Construction Company, 46 Wall street, on the top floor. Mr. Brown has been quite busy making arrangements to supply the State authorities with the apparatus needed for electrical execution, and hence he has been out of town, much to the disappointment of Mr. Jim Godfrey, who has been wanting to see him. Mr. Godfrey says he is much obliged to Mr. Brown for the publicity given by him to the Grimshaw, wire in connection with the accident in the Hudson River Tunnel, but he rises to remark that at the time of the death of the workman, there did not happen to be a foot of his wire in the tunnel.

Wires in the Hoosac Tunnel.—Mr. Edward Davis, expert for the Marr Construction Company, Philadelphia, has reported to Mr. H. M. Doubleday, its vice-president and general manager, with regard to the results obtained from the use of the P. & B. compound on the wires and cables in the Hoosac Tunnel, where the difficulties of insulation are remarkably numerous and severe. Mr. Doubleday finds that the compound is a good protection against acids, etc., which had attacked the cables. With regard to its insulating and waterproofing properties, he says that during the summer of 1888 four joints were made in the cable with rubber tape, painted inside and out with P. & B., and thrown into water. This line was run during a period of four months with 1,000 volts E. M. F., and never gave the slightest trouble. When it was taken up, so that the temporary joints might be replaced with permanent ones, no action whatever was observable on the joint.

The New Sprague Railway Switch.—A new electric switch for street railway work has just been brought out by the Sprague Electric Railway and Motor Company which will simplify and make more compact than ever the method of controlling railway motors on street cars. The hand movement required to operate this switch is extremely limited, so that in case of emergency the motor can be stopped and reversed in an exceedingly short space of time, reducing all possibility of collision with another car or with any possible obstruction on the track to a minimum. The new switch is entirely fire and moisture proof, is only about one-half the size the present railway switch and is arranged so that it can be carried between the car wheels, underneath the flooring where it is entirely out of the way, and where it occupies no valuable room on the platform. The control is by a vertical rod, passing up from the switch-box to the platform, looking exactly like a brake-rod. A movement forward of this handle for the space of a quarter of a circle means ahead at full speed. A reverse movement of the same amount means backing at full speed, and there are all the combinations between, so that it is possible to regulate the speed of the car to any degree desired. This improved switch does away with all through wiring in the car, all possible sparking inside of the switch, is the most compact form imaginable, and is a marked improvement over any other style of railway switch, it is claimed. In case of any obstruction upon the track, the advantages of the improved switch over methods of controlling the motors by means of a rheostat are very evident. The natural tendency in case of an expected collision is for the driver to jump back from his dash-board. By this movement he will carry his lever-handle with him, instantly reversing his machine without giving it a thought, and avoiding all trouble. I understand that this switch will be introduced upon all the Sprague electric railways which are now in course of construction. W. T. H.

NEW ENGLAND NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
Room 8, Cook Building, cor. Franklin and Congress Sts.
BOSTON, May 25, 1889.

Mr. W. J. Morrison, general agent for the Fort Wayne Jenney Electric Light Company, was in town this week.

Mr. S. C. Peck, manager of the Citizen's Electric Illuminating Company, Brooklyn, N. Y., is spending a few days in town.

Chelsea, Mass.—Electricity has won a signal victory over other forms of illumination at Chelsea, Mass. The idea of a municipal plant has been given up, but the electric light will still reign supreme in that town, whose modern Athenian pronunciation is "Chelsy."

Newburyport, Mass.—This city will soon enjoy the facilities offered by an electric street railway. The eminent success of electricity as a motive power for street cars in the larger cities of New England is causing the smaller towns to swing into line in rapid succession.

Messrs. Paine & Francis.—Messrs. Paine & Francis are installing an Edison isolated plant in the Ames building, Boston; also a plant of 1,000 lights in the depot at Springfield, Mass., which, when completed, will be a practical testimonial to this firm of more than usual significance.

New England Life Insurance Building.—This building is now lighted throughout by the Edison system, and besides being far superior from an artistic standpoint, the innovation will be appreciated by those who have thus far been compelled to work under the flicker and heat of gas lights.

The Martin Thermocall.—I notice a number of these accurate little instruments (described in THE ELECTRICAL WORLD of May 25) in use about town both as a temperature regulator and as a thermometer. The instrument is so sensitive, accurate and cheap that it is naturally enjoying a brisk demand.

Woburn, Mass.—The legal difficulties between the New England Telegraph and Telephone Company and the Woburn Electric Light Company having been settled, the latter company will proceed unmolested in their construction work. This company have secured a three years' contract for lighting the city.

Electric Power for Portland, Me.—A great scheme is on foot to transmit power to Portland electrically from water power as a source. Messrs. S. D. Warren & Co. are preparing to push the matter not only for their own use at Cumberland Mills but for the use of Portland. The plan is certainly economically and practically feasible, and the city of Portland will doubtless enjoy the advantages of cheap and sufficient electrical power at an early date.

New Elevated Road Bill.—It was thought when the elevated-road bill was defeated last week that the scheme had disappeared from sight for a year at least. Hardly had the original bill been defeated before it was again introduced in a modified form, only to be again defeated on a point of order. Now it again appears under the title of a bill to incorporate the "Boston Electric Elevated Railway Company," and those interested are hopeful and confident, notwithstanding the adverse action thus far encountered from the Legislature.

Thomson-Houston Motors have recently been sold as follows: G. W. Dickinson, Providence, R. I., 1½ h. p.; Franklin Electric Supply Company, Pittsburgh, 5 h. p.; Lewiston & Auburn Electric Light Company, Auburn, N. Y., 7½ h. p.; Wall & Oches, Philadelphia, 1½ h. p.; Geo. G. Storm, Providence, 1 h. p.; Ellsworth Electric Light Company, Ellsworth, Me., 15 h. p. and 5 h. p., and a generator of 50 h. p.; Nicholson, Frost & Co., 10 h. p.; Booth & Hutchinson, Providence, R. I., 1½ h. p.; B. F. Haley, Dover, N. H., 1½ h. p.; Julien Electric Light and Traction Company, a 3 h. p. and a 4 h. p.; Jacob Wirth, Providence, R. I., 1½ h. p.; John C. Kerr, Philadelphia, Pa., 1 h. p.; Thomas Todd, Boston, 3 h. p.

Taxing Patented Properties.—A bill is now before the Massachusetts State Legislature, which, if passed, will tax all patented property in this State. The true inwardness of the bill is this: The Lamson Store Service Company rent in the city of Boston alone property valued at $200,000, none of which can be taxed as the law now stands, as the company is to be incorporated under the laws of New Jersey. In order to tax this property, it will be necessary to pass the sweeping law as above described—a strabismus of justice that will have an easily-predicted effect upon other patented property in this State. It is generally conceded that the bill will not become a law.

Electrical Stock Quotations.—R. D. Wilson & Co., dealers in electrical stocks, securities, bonds, etc., 113 Devonshire street, quote the following prices on electric stocks closing May 23:

	Bid.	Asked.
Thomson-Houston Elec. Co.	85	86
" " International, com.	125	130
" " " pref'd.	101	102½
" " Carbon "	.....	125
" " Series C.	18½	19
Thomson Electric Welding Co.	365	370
Westinghouse Elec. Co.	56¼	57
Bell Telephone	241½	242
New England Telephone	47½	.....
Erie Telephone	34	.....
Mexican	65c.	70c.
Edison Phonographic Toy Mfg. Co.	9	9¼

Simplex Electrical Company.—Dr. Mason, of the Simplex Electrical Company, has just returned from a most successful trip in the West. Starting with New York, Dr. Mason visited Chicago, Louisville, Cincinnati, Pittsburgh and other Western cities, in all of which he reports a large demand for his wires, culminating with an order of 300 miles of line wire secured in St. Louis. This wire is to be used for the city contract, which calls for 2,250 arc lights, located by the city engineer. Though the present order is for 300 miles, about 600 miles will eventually be required, and Dr. Mason tells me he has the contract to furnish the whole quantity. This order will tax the Simplex company's manufacturing resources for the present, though, from their three factories, they can ship, outside of other orders, about 100 miles a week, without being unduly pressed.

The Spencer Damper Regulator.—Mr. G. G. Stillman, of 19 Pearl Street, Boston, reports the following recent sales of the Spencer damper regulator, for which he is agent: El Callao Mining Company, 2 regulators, South America; Windsor Cotton Company, Windsor, N. S.; Arlington Mills, Lawrence, Mass.; Washington Mills, Lawrence, Mass.; N. E. Conservatory of Music, Boston, Mass.; Emerson Piano Company, Boston, Mass.; Waterbury Clock Company, Waterbury, Conn.; Waterbury Watch Company, Waterbury, Conn.; Smith Granite Company Westerly, R. I.; S. B. Champlin & Son, Providence, R. I.; The Hanover, New York City, N. Y.; Hotel Bristol, New York City, N. Y.; Potter Building, New York City, N. Y.; North Hudson County Railway Company, Hoboken, N. J.; Stevens Castle, Hoboken, N. J.; Electric Light Company, Somerville, N. J.

The Thomson Scientific Club.—The organization of the Thomson Scientific Club was perfected at Lynn on Monday evening May 20. The objects of this club as set forth by its Constitution are to disseminate scientific, technical and kindred knowledge among its members, to promote the general interest of its members in acquiring such knowledge, to extend social and scientific intercourse among its members by providing a suitable place of meeting, a library and such other appurtenances as may be found desirable. The Club is made up at present of the employés of the Thomson-Houston Electric Company, and the Thomson Electric Welding Company, although its doors are open to others who are interested or engaged in scientific, technical or kindred pursuits. Over eighty persons have already signed the constitution. The officers are as follows: President, Prof. Elihu Thomson; 1st Vice-President, E. Wilbur Rice Jr.; 2d Vice-President, Chas. J. Van Depoele; Secretary, H. Bottomley; Treasurer, W. S. Gorton; Reviewer, G. F. Curtiss. Executive committee: W. H. Blood, E. E. Boyer, C. F. Medbury, J. E. Randall, J. Riddell.

New Electric Light Station at Springfield, Mass.—I notice in the Springfield *Daily Union* of May 18 a partial description of the new electric light station in that city, and in some curious way many points of excellence in the equipment and design of the plant were credited to one who was an assistant of the designer at the time the main features of the station were decided upon and carried out, and who had almost nothing to do with the installation. In order to correct this article, which must have been written under a misapprehension, I would simply state that everybody knows that to Mr. Alexander P. Wright, late superintendent and manager of the Springfield Electric Light Company, is due the credit for the design of the perfectly working underground system, the essential features of the switch-board, which the *Union* describes as "the finest in the country," and most of the other novel and practical features of this remarkably fine plant. Of course this installation can be extended, and perhaps improved, but it seemed almost incredible to me that some one should have furnished data to a newspaper on the spot to the injustice of one whose credit for the work is so well known and appreciated.

Armington & Sims Engine Company.—At the annual meeting of the Armington & Sims Engine Company last week, the treasurer presented his annual report, showing a largely increased prosperity through the year and a large number of unfilled orders on hand. Notwithstanding the force has been largely augmented, it has been unable to keep up with the demand at any time during the year. An especially gratifying feature of the business is the growing demand for the engine for use on board of vessels of the United States Government. Quite a large number of the engines are now in use in the navy, and several are now in process of construction. Orders also continue to arrive from Europe. The treasurer advised the customary semi-annual dividend of three per cent., which was subsequently declared. The following Board of Directors was elected: Royal C. Taft, John W. Danielson, Henry C. Cranston, Pardon Armington, Gardiner C. Sims, Henry Howard, Rowland Hazard, Charles T. Howard, Jeffrey Davis, James E. Cranston. At a meeting of the directors, held subsequently, James E. Cranston was elected president; J. W. Danielson, vice-president; Pardon Armington, treasurer; H. C. Cranston, assistant treasurer; Gardiner C. Sims, general manager; Theodore Andrews, Secretary.

The Wainwright Manufacturing Company, of Massachusetts, is a new corporation organized under Massachusetts laws. This company succeeds the Wainwright Manufacturing Company of Medford, Mass., and will continue the manufacture of heaters, filters, surface condensers, expansion joints and corrugated copper and brass tubing, besides doing a general foundry and machine business. It is composed of some of the best business men of Boston. It will be the aim of the company to put out the best goods at a low cost. A high standard of excellence in all its manufactures will be maintained, and the best of workmanship employed and material used. Their manufactures are all guaranteed. They use exclusively the corrugated tube, which has been proved so efficient in feed water heaters and condensers, and in any machine where a quick transmission of heat is essential. They are now building six different styles of feed water heaters, of which there are over 60,000 h. p. in use in this country, South America, Europe and Japan, namely, coil heaters, straight tube heaters, horizontal, vertical, and heaters for compound engines. Their heaters are built in all sizes, from 8 h. p. to 2,000 h. p. Among the large heaters now in use, I may mention of the following: Middlesex Electric Light Company, Lowell, one 500 h. p.; Thomson-Houston Electric Company, Lynn, one 500 h. p.; Thomson-Houston Electric Company, Lynn, one 400 h. p.; Swarzschild & Sulzberger, New York, N. Y., one 500 h. p.; East End Electric Light Company, East Liberty, Pa., one 500 h. p.; Palace of the Mikado, Yeddo, Japan, one 500 h. p. F. R. C.

PHILADELPHIA NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
31 City Trust Building, Philadelphia, Pa., May 25, 1889.

Mr. F. Brophy, son of Capt. Brophy, the well-known inspector for the underwriters for New England, was in this city last week, the guest of Inspector McDevitt, of this city.

Burying Wires.—The Merchants' Electric Light Company, recently organized to serve residents of Kensington and vicinity, are anticipating the inevitable edict of City Councils, and are placing their wires underground. Service will be given in a few weeks.

Langhorne and Holmville are two Bucks County towns that have their streets lighted with incandescent lights, and the worthy citizens of these boroughs are very proud of their enterprise in adapting this modern style of artificial illumination. The Thomson-Houston system is used.

The "Sylvan Glen's" Plant.—The contract for lighting the steamboat "Sylvan Glen" has been awarded to Messrs. Walker & Keppler, Edison agents and contractors. The plant will be of 100-lights. The boat is now owned by the Gloucester Ferry Company, of this city, who have made extensive repairs in the fittings.

Messrs. C. W. Arnold & Co. have leased a factory at Chester, Pa., and are fitting it up preparatory to the manufacture of dynamos, motors and electrical specialities. They also intend building the Arnold engine for direct coupling, which has been tried with such satisfactory results on board the yacht "Restless," owned by Editor Singerly of the *Philadelphia Record*.

The Thomson-Houston Electric Company has just sold a fifteen arc light plant to the Edison Electric Light Company, of Chester, Pa. This company has a contract with the city for street lighting, and is using the municipal system with good results. The purchase of the arc machine was caused by the demands of some merchants, who wish to illuminate their stores with the arc light.

C. M. Rhodes, manufacturer of dynamos, motors, etc., at No. 127 North Seventh street, reports quite a good demand for his line of goods. His chief specialty is the Rhodes motor, which is made from 1-12 h. p. up to the regular sizes. He also makes the Law lightning arrester, which is meeting with quite a ready sale. He is preparing a new line of goods, which he will shortly catalogue and offer for sale.

Messrs. Jennings & Kern, of No. 109 N. Third street, are out with a new compound, which they style "Chromic Paste," for recharging old cells and renewing their life. They claim that with a trifling cost, an old cell can be made nearly as good as new. It can be used with either open or closed circuit batteries at very little trouble. The paste will be ready for sale in a few weeks, put up in packages to suit the trade.

Mr. H. T. Paiste, the well-known manufacturer of switches and insulated cut out joints, is making arrangements for a two-months' tour of England and the Continent. Part of his time abroad will be devoted to looking after his exhibit of switches, etc., in the Paris Exposition, and the remainder will be devoted to sight seeing. His present programme provides for his leaving New York on the steamship "Umbria," which is billed to sail June 8.

Messrs. J. W. Queen & Co., makers of electrical instruments, etc., have just closed a contract for the manufacture of 200 automatic switches for one company. These will be of a new design. This house is getting more and more into the manufacture of electrical supplies, and under the able directorship of Mr. Joseph J. Walton, who superintends the electrical department, will soon be bidding for the leadership. Their business in instruments for electrical work is growing rapidly and is, without a question, one of the largest in the country.

Safety in Electric Lighting.—The danger from fires caused by the introduction of the electric current into stores, dwellings, etc., in this city has been obliterated, judging by the report of Inspector McDevitt. He says that during the past year not one dollar has been paid for damages by fire caused by electricity and that too in a section which has over thirteen hundred houses using the current. Some of the buildings have been wired over eight years, which certainly speaks well for the character of the work done and the careful inspection after completion.

To Belt the West.—Five miles of leather belting is hardly conceivable at first glance, but reduced to units 26,400 feet means a good deal of leather and quite a quantity of money. This amount represents an order which John W. Pechin & Bro. are making up and sending to their Western customers. Since this firm began making their justly famous "Dynamic" belt for electric light service, their trade has increased greatly, not only among the Eastern trade, but all through the West, where THE ELECTRICAL WORLD has carried their name and business.

Underground Work.—The sub-committee of councils dealing with the removal of telegraph, telephone and electric light wires from the streets have notified the railroad companies having overhead wires to put them underground. Representatives from all the companies, stated to the members that, if it were feasible, the order would be obeyed, provided that none of the companies' rights were interfered with. Before the same committee, it was stated that wires for arc circuit could not be buried successfully, and Professor W. D. Marks, general manager of the local Edison Company, testified that as experiments have demonstrated that it can be done, the question was one of fact, not of theory.

J. Elliott Shaw & Co., makers of electrical appliances at 53 and 55 North Seventh street, this city, are out with a new and very complete catalogue of their goods. Some of their latest designs are an annunciator indicator worked by gravity; an electric gas-lighting burner controlled automatically; a heavy stroke bell worked by a double armature; door spring of an improved design, and other improvements of various kinds. Their well-known line of Norway iron bells has been augmented by the addition of several new shapes of bell, and they have added new ideas to all their specialties. A new article being introduced by this house is the Burgess' blow-pipe pump, for use in hard and soft soldering of electrical wires and connections, tempering of tools, lead burning, etc. The machine is light andportable, and is intended to replace the old-fashioned bellows.

The Masonic Temple.—The committee having in charge the lighting of the magnificent Masonic Temple, at Broad and Filbert streets, have decided to allow the local Edison company to furnish the necessary current from its central station on Sansom street. The building will be wired for over one thousand lights, and it is reported that Bergmann & Co., of New York, will furnish the fixtures. This plum was eagerly reached for by all the electric light companies, and as each guaranteed about the same features, the committee found it an impossible task to render a judgment, so the vexed question was decided by allowing the local Edison company to furnish current from its street mains. This method will be given a fair trial, and if it is found to be as efficient and just as cheap as an isolated plant, everything being considered, it is probable that a contract for a term of years will be signed.

The International Printing Telegraph Company.—The stockholders of this company met in Camden on last Thursday, and for three hours discussed the company's prospects and each individual's chances for deriving some benefit from the stock already purchased. Dr. Agnew, the chairman, reported that 491 shares had already been subscribed for, and 2,000 more are expected to be sold to New York parties. Motions that all the stockholders be advised of a special meeting by advertising and by printed circular were successively defeated, and the discovery was made that Mr. Harned, one of the company, had taken possession of the subscription book, which he would only relinquish for the sum of ten dollars, cash in hand. This threw a damper upon the meeting, until an announcement was made that two Camden parties had agreed to take 1,000 shares of stock each at $2.50 per share, and the meeting adjourned amid enthusiasm. It was privately stated after the meeting that all proceedings against the company had been postponed until June 3.

The Erie City, Pa., Passenger Railway Company are rapidly progressing in the work of equipping their road so as to be operated by electricity. Their power station, which is almost completed, is to consist of two 150 h. p. return tube boilers and two of the well-known Ball engines of 150 h. p. each, which are to drive four Edison dynamos, each of 50,000 watts capacity. The company have ordered thirty cars, each of which will have two 15 h. p. Sprague motors, except a few that are intended to run on the more level portions of the road. These will have but one motor of 15 h. p. The whole 13 miles of track has been relaid with the Johnson patent girder rail, and no expense has been spared to make the road as perfect as possible. The trolley wire, which is to be No. 4, will be suspended directly over the track from poles on both sides of the street. There are to be several "feeders" run out; some of these are No. 2, others No. 4 wire. When completed, which it will be about the middle of June, Erie will have street car accommodation equal, if not superior, to that of any city in the country.

Electric Street Railways for Pittsburgh.—Among the charters granted by the State Department at Harrisburg this week, were two incorporating street railway companies to do business at or near Pittsburgh, Pa. Each of the charters provides for the employment of the electric current for energy and it is probable that both will be equipped with the overhead system. One of these companies is the Bellevue and Pittsburgh Street Railway, which will be eight miles in length. The incorporators are well-known Pittsburgh capitalists and have subscribed $48,000 with which to commence operations. The other one is styled the Diamond Street Railway Company, of Pittsburgh, and will be five miles in length. Its incorporators are also well known in financial circles, and they have determined that $300,000 would be sufficient to build their road. Both these roads are intended for suburban traffic, and it is of the highest importance that the transit should be rapid. The reports on electric railways which show them capable of running anywhere between one and twenty miles an hour with perfect safety and ease of transit makes this system a powerful competitor for favor with the Pittsburgh people.

The Cohen System.—The National Electric Light and Power Company, owner of the Cohen patents for dynamos, motors and all kinds of electrical apparatus, has just issued a prospectus and catalogue. The book is very ornate in appearance, and full of electrical "meat." The company illustrates its present styles of incandescent and arc motors, arc lamps, etc., and shows also a good cut of the Cohen armature. A new factory has been secured at the southeast corner of Dilwyn and Green streets, this city, and is being fitted up with suitable machinery for the manufacture of elegtrical appliances. It covers an area of 50 by 45 feet, is two stories in height, and has now a 40 h. p. engine which will be duplicated very shortly. The main offices will continue at Nos. 66 and 68 Bullitt Building. Since its incorporation the company has met with excellent results, and quite a number of its machines are running very successfully. The latest installation was a 15-light machine for Morse, Williams & Co., elevator makers, at No. 1105 Frankfort avenue, this city, which will be used for lighting up the basement and dark corners of their factory. This is in addition to a 200-light dynamo which was placed in position last year, and which gave excellent service during the fall and winter months.

E. F. C.

WESTERN NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
44 Lakeside Building, Chicago, May 25, 1889.

Mr. Charles Sutter, of St. Louis, says that the talk about the failure of his company to carry out his big contract for city lighting is all bosh.

St. Louis, Mo.—A fire occurred at St. Louis on May 20 in the cupola of the Western Union Telegraph office, when considerable damage was done.

The Electric Holder Company has been formed at Chicago by A. H. Bacon, F. C. Hoyt and E. W. Banister with a capital stock of $5,000 to make "electric holders."

The Colby Electrical Manufacturing Company has been formed at Chicago by E. J. Colby, H. J. Hayes and F. W. Parker with a capital stock of $100,000.

Argentine, Kan.—The Argentine Water and Electric Works Company has been formed by T. J. Enright, A. Klein and J. P. Byrne, with a capital stock of $150,000.

Hays City, Kan.—The city council has granted a twenty-five years' exclusive franchise to the Hays City Electric Light Company, the lights to be put in within six months.

Fort Scott, Kan.—The Fort Scott Electric Light and Power Company, Mr. Thompson, superintendent, has a good plant, and proposes with the aid of outside capital to enlarge its business.

Vincennes, Ind., lends its encouragement to Superintendent Freund, of the Electric Light Company, for the erection of a fine line of 40-foot poles, and a local paper says: "The people of Vincennes ought to be very indulgent to an institution that has so reduced the cost of lighting."

Redwood City, Cal.—The Redwood City Electric Light Company has been formed with a capital stock of $20,000. The directors are: A. J. Marcus, Moses Hopkins, G. H. Rice, A. L. Fulton, Albert Hanson, P. P. Chamberlain and J. A. Ross. The company will operate a Ball plant.

Spokane Falls, W. T.—The Ross Park Electric Street Railroad Company will have a Thomson-Houston plant running by August, with four miles of track and six cars. Mr. G. B. Dennis is president; Mr. E. J. Webster, vice-president; Mr. C. L. Marshall, secretary; Mr. H. N. Belt, general manager, and Mr. S. Heath, treasurer.

Telephone Quotations.—Col. S. G. Lynch, broker, 146 La Salle street, furnishes quotations upon telephone stocks as follows:

Bell of Mo.	$150@$153	Iowa Union	$22@ $25
Central Union	50@ 51	Michigan	81@ 82
Chicago	300@ 305	Mo. & Kansas	65@ 67
Colorado	39@ 40	Rocky Mountain Bell	40@ 41
Cumberland	67@ 69	Wisconsin	116@ 117
Great Southern	31@ 33		

St. Louis.—An electrical railway franchise was asked for on the 9th inst., in the municipal assembly of St. Louis. The line is to start from the intersection of the old and new Manchester roads, and run to Benton Station, a distance of about four miles. Several very prominent citizens are among the incorporators. A bill for the appointment of several electric light inspectors will probably be passed by both houses in the course of a few weeks.

The Border Telephone Company, of Pleasanton, Linn County, Kan., has been incorporated with a capital stock of $10,000 divided into shares of $50 each. The purpose is to construct, maintain, and operate telephone lines, exchanges and stations in all the counties of Kansas and Missouri. The directors are W. O. Fuller, George C. Wyncoop, R. T. Thorne, Robert Kincaid, C. F. Simmons, H. W. Underhill, G. R. Saunders, R. W. Blue and A. Baker.

Decatur, Ill.—The Decatur electric road is being equipped by the Fisher-Rae Company, of Detroit. The main track has already been laid with 38-pound Johnson girder rail, and the poles have been put up. There will be six 16-foot Pullman cars. The power house is 35 by 45, of brick. The engines have been built at Lansing, Mich. The franchise calls for two miles of road to be running July 30, and includes both lighting and power. It is considered a valuable concession, and it will be well taken care of by the installation of a plant first-class in every respect.

Cincinnati, O.—The Edison Electric Light Company have filed a suit against the First Edison Electric Illuminating Company, of Cincinnati, for recovery of dividends to the amount of $2,150. The plaintiff company says it is the owner of eighty-six shares of the capital stock of the defendant company, and, as such owner, is entitled to receive the dividends declared thereon; but on the 11th day of February of this year a dividend of ten per cent. was declared by the defendant on its stock, and on the first day of the present month another dividend of fifteen per cent. was declared, neither of which has been paid to the plaintiff.

The Electrical Supply Company, of 171 Randolph street, have just issued a new catalogue, No. 647, of electrical house goods supplies. Besides showing a most complete line of batteries, bells, buzzers, annunciators, etc., they have included a full line of electric gas-lighting apparatus, tools, many of which have been specially designed for themselves, and are peculiarly adapted for use of house electricians, the most complete set of circuits which I have ever seen, directions for wiring, etc. I think this catalogue will be much appreciated by those in the electrical business, and it is but another evidence of the brainy and nervy management that is rapidly pushing the company ahead.

The Ellis Oil Filter is being put on the market by the Electrical Supply Company for use in electric light stations. The filtration of oils has become one of the regular processes of station work. Filtration not only *restores* oil, but, if properly performed, will be found to increase its lubricating qualities. The oil is heavier and will stand more temperature and actual velocity of the rubbing surface than before its filtration. The economy in using the oil filter appeals to the common intelligence of any one who has seen the indiscriminate use and waste in enormous quantities of oil handled in electric light stations. The use of a filter permits of an abundance of oil being used which will give certainty of cool journals. The Ellis is specially recommended for such work.

Taxation in Tennessee.—By a bill just passed by the Tennessee legislature, electrical interests are to be taxed as follows: Electric light companies, in cities, taxing districts, or towns of 30,000 inhabitants or over, each, per annum, $100; 8,000 to 30,000 inhabitants, $75; less than 8,000, $25. Telegraph companies (in lieu of all other taxes except ad valorem tax): Each company operating 300 miles or more of telegraph wire, for one or more messages sent from one point in the State, and not sent in the service of the United States government, per annum, $3,000; from 100 to 300 miles of telegraph wire in this State, $300; from 25 to 100 miles of telegraph wire in this State, $25. Telephone companies: Each telephone box, per annum, 50 cents.

St. Louis Matters.—A St. Louis correspondent writes: "The city of St. Louis has been warned by the Brush Electric Light Company, Cleveland, O., not to accept the bid of the Electrical Accumulator Company, for lighting the city's streets, for the reason that the Accumulator Company will employ a double carbon device, which the Brush Company claims as its own. The Accumulator Company answered that they have got permission from the "Jenney" Company from Indianapolis to use this carbon device, and that the trouble arises from the fact that there are two "Jenney" companies, one at Fort Wayne, and the other at Indianapolis. The Indianapolis Company has the right to use the double carbon device, but the Fort Wayne Company has not. In the meantime, the city is going slow in the matter."

The Pond Engineering Company, of St. Louis, have begun work on the foundation for the 125 h. p. Armington & Sims engine, for the Metropolitan Street Railway of Kansas City. This road is to be in operation by July 1. The engine has already arrived, and as soon as the foundation is completed it will be set up and connected to the boilers. The same company has just supplied the Union Railway Company of St. Joseph with two Armington & Sims engines. They will be erected in the course of the next few days, the rest of the plant not being quite ready. The Pond Engineering Company have moved their Chicago quarters from 51 Home Insurance Building to 427 "The Rookery," where permanent quarters have been secured. They report a large number of inquiries for complete steam plants, which are their specialty.

Underground Wires in Detroit.—The Cole Conduit Company, of which Wm. B. Moran, James A. Randall, James A. Phelps, Ralph Phelps and Charles B. Cole are officers and sole owners of the $75,000 capital, all paid in, will begin on June 1 to construct subways in Detroit for carrying electric wires underground, under the Cole patents. The subways consist of an outer coating of wood, the largest being 8 by 8 inches, all parts of which are coated with pitch or tar before being put together. The interior ducts are saturated with paraffine at a high temperature. The interior space is filled with a plaster, flexible, water-proof insulating compound, which, it is claimed, prevents any escape of the electric current. The wires, either singly or in cables, are placed in the centre. Manholes are placed at convenient intervals, to allow of changes and manipulation, and wires can be strung or removed with facility. One of the forms of Cole's conduit has been tested by the Detroit Fire Commissioners, who, it is stated, have ordered 1½ miles for the service of the department. Another form is suitable for arc electric light wires.

An Epistolary Lineman.—J. H. Ormund writes as follows to the St. Louis *Republic*: "As a lineman and reader of the *Republic*, would you be kind enough to allow me to say a few lines in your paper in regard to the dangers that we telephone and telegraph linemen have to undergo every day. Now, the whole trouble is this: The electric light wires in this city have been put up in such a bad way that a man is liable to get caught at almost any moment. They may try to give the people the 'stiff' that they are insulated, but any one who is acquainted with the business knows better. There are any number of places where the insulation is worn off, especially on the poles, and the wires are run in such a shape on some of the poles that it is impossible to get past them without touching them and running the chance of going through the same terrible experience of the poor fellow that was killed at Eighth and Pine streets yesterday afternoon. We would like to know what the City Inspector has been drawing his salary for? It is about time the people understood this thing. So, hoping you will show this thing up in its true colors, respectfully yours."

Carthage, Mo., is enjoying the first symptoms of a boom. Both lead and zinc ores have been found in paying quantities, and three mines are now in operation. Land in the immediate vicinity has increased many times over in value. Wm. B. Meyers, Mayor of this good city, is the owner of several acres of mineral land, and is rapidly preparing to ship ores to the smelter. Every one rejoices with him in his good fortune, as his popularity is unbounded. Mr. Meyers is also the president of the Carthage Electric Lighting & Power Company, operating forty arc lights of the Sperry system, and is now installing a storage battery plant in the Harrington House of 104 Detroit cells of type 15 M. The charging current will be furnished by a dynamo specially wound for this work by the Sperry Electric Company. This dynamo is placed in the electric light station, and is operated during the daytime, the current passing over the regular circuit to the hotel, where a special switch cuts the battery circuit in or out. One hundred and twenty 16 c. p. lamps are to be operated as soon as

the circuit is completed. A great deal of interest in storage batteries is being taken in this section. J. F. Pilgrim contemplates putting in a plant at Monett, Mo., and J. Guinney is now arranging for a plant at Pierce City, Mo., which is to be in operation within sixty days.

KANSAS CITY, Mo., May 16, 1889.

Mr. C. S. Rusling, the Thomson-Houston agent here, has been east for the past week, being called there by the severe illness of his father.

The Edison Light and Power Company are now ready for furnishing all kinds of electric light and are soliciting power contracts. Until their new plant was put in operation, this kind of business was only taken when forced on the company, but now they consider themselves well equipped for it. They are operating four 1,000 light machines and will have two more in by the end of this week.

The Telephone People have escaped from the legislative labyrinth and after a five months' worry are still uninjured and still in the ring. The rate bill was killed some weeks ago, but a bill to delegate the power to control telephone business to the various cities where the exchanges were located, had been introduced and was favored by the higher branch of the legislature but killed in the lower one.

Electrical Executions.—The recent horrible hanging of the Bald-Knobbers at Ozark, has revived interest in electrical executions, and were it not for the fact that the Missouri Legislature is on the point of adjournment, it is probable that some bill would be introduced to prevent an execution from being an experiment. Every paper has referred to the New York idea, and the alternating system has received considerable free advertising of a mortuary kind.

Col. C. F. Morse, the president of the Metropolitan Railway Company, which owns and operates over half the street railway mileage in Kansas City, said in an interview last Saturday: "We expect to operate the Armourdale line by electricity in the early part of June. It is highly probable that should the Armourdale line prove a success the Rosedale line will be the next to be operated by electric power, as there are no heavy grades on that line." The street construction is already completed on the Armourdale line, which is two miles long. The Rosedale line is about four miles long.

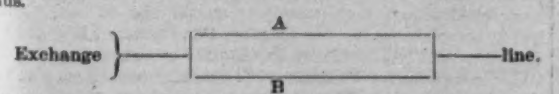
Telephone Legislation.—It is probable that this week will see the last of the present Missouri Legislature, and the telephone folks will then be able to breathe more easily. The rate bill was defeated, but there is danger that the power to regulate the business of the telephone companies may be delegated to the various cities, towns and villages where the exchanges are located. If this be done it will mean that there will always be a fight on hand at some point or other. Instead of the telephone folks having a fight on their hands once in two years, when the Legislature is in session, the war will be a continuous one, and would undoubtedly result in closing many small exchanges.

Pierce City, Mo.—Mr. C. S. Rusling, the agent of the Thomson-Houston Company, has secured contracts for furnishing a plant at Pierce City, Mo, of 30 lights of 1,200 c. p. and 200 incandescent lights; for a 50-light incandescent plant for the Western Sash and Door Company, of Kansas City; for a 400-light incandescent plant for the town of Tarkio, Mo., and for a 50 arc light increase in the Troost Park plant, of Kansas City. Mr. Rusling reports that he has quite as much correspondence to attend to on the subject of electric railways as on the subject of electric light. It has become evident to all street railway men that animal power has had its day, and its only practicable successors are the steam motor, the cable or electricity. A director of the Metropolitan Street Railway Company, which operates more than half the street railway mileage here, said that before their last cable line was half completed the board regretted its decision and was sorry it had not awaited developments in electricity. The cable line referred to was put in operation nearly a year ago, and the company have already let a contract to equip two miles of one of their horse car lines with electricity, and will give the system a thorough test.

Pole Cutting Policy.—The summary action of Mayor Grant, of New York, in having the poles and wires forcibly removed from the streets has undoubtedly set a number of the managers of electric light companies in other cities thinking. Should Mayor Grant's action prove beneficial in every way, there will be a nearly simultaneous howl from every large city in the country, and each mayor will be almost forced to follow Mr. Grant's precedent. Mr. E. R. Weeks, the president of the National Electric Light Association, was asked what would be his plan if the agitation should break out in Kansas City. "I should do my best to try and convince the people that I was trying my best to get the wires under ground," said Mr. Weeks. "I know that there are many difficulties in the way of operating underground wires, but the people don't know it, and they won't believe it, until they see an attempt and a failure made. I should put down an experimental piece of conduit in the best possible manner and operate it if I possibly could. The experiment would be cheaper than that of chopping the poles down.

"I think," continued Mr. Weeks, "that both parties in the New York contest have been rather blameworthy. It seems as if the corporation and the light companies ought to have been able to get together and arbitrate that difficulty to a conclusion, which would have been much more satisfactory to each than this present solution, that has settled only one end of the question."

Mr. Alfred Barrett, the electrician for the Missouri and Kansas Telephone Company, has designed a device for greatly neutralizing induction and which has been applied on some of the noisy lines running out of the Kansas City exchange and extending into the country. It consists in merely dividing the wire and running one branch of it down one street and the other down another, thus.



The greatest induction which a line gets in running from a city exchange into the country is in the city itself. After the line reaches the suburbs there is little to disturb it, so the route through the city is divided, part going down one street A, and part, a block or more distant, on street B. The vibrations of the induced currents on A and B are never in unison; if they were the noise would be increased, but a very large proportion of these vibrations meet and neutralize each other. Although the noise is not annihilated, it is so greatly reduced, that several lines running out of the Kansas City exchange, which have hitherto been almost useless after nightfall, when the electric light begins operations, have been rendered quite serviceable.

LOUISVILLE, Ky., May 13, 1889.

The Louisville Electric Light Company is installing two new Westinghouse machines possessing the capacity of 750 lights apiece.

Dr. Norvin Green, President of the Western Union Telegraph Company, has been spending the past few weeks at his home in Louisville.

Electric Lighting.—Louisville has two electric light plants in operation. The city government has taken measures towards securing electricity for more extensive street illumination, and a third electric light plant is being projected.

The Kentucky Phonograph Company has located at No. 246 Fifth street, with a capital of $400,000, and the following officers have been elected: J. C. Scott, manager; H. V. Loving, president; L. Leonard, vice-president, and Oscar Fenley, secretary and treasurer. Phonograph No. 72, which has been on exhibition at the Gaynor Electric Company's office, has been returned to New York where, it is stated, it will be destroyed.

An Electric Road.—Louisville will have the first electric railway in operation in about two weeks. It reaches the full length of the city from east to west, and is five or six miles in length. The trucks have arrived; the cables, both overhead and underground, have been placed, and the plant for the station is being got ready. Two Thomson-Houston machines, of 80 h. p. each, will furnish the motive power. B. Dupont, the street railway magnate, is building the road. E. E. Vining, of Boston, is employed in placing the electrical apparatus.

B.

SOUTHERN NOTES.

CHATTANOOGA, Tenn., May 18, 1889.

Chattanooga is progressing electrically as well as in every other way. The building of the big river bridge is now a certainty, as the County Commissioners are advertising for bids. The Sprague electric railway to the National Cemetery and Missionary Ridge is almost ready to start its handsome cars, which have arrived. A company to build an electric railway on the top of Missionary Ridge from Sherman Heights to Rossville Gap has been chartered, and the right of way has been secured. Lookout Mountain will be the next to be brought under the sway of electricity.

The D. M. Steward Manufacturing Company are filling an order for 50,000 pieces of their patent lava insulators for the Thomson-Houston Company, Lynn, Mass., and they also have a number of orders in hand for other concerns, covering the entire United States, and customers still continue to voluntarily say, "Your insulation is the only thing we have found so far that meets our requirements, and we believe it to be the only insulation that will stand the extremes of heat and moisture, sea air, etc."

ENGLISH NOTES.

(From our own Correspondent.)

LONDON, May 8, 1889.

Underground Conduits.—A few weeks ago English electricians were told at great length in Prof. Forbes' paper on "European Central Stations and Their Lessons," what *not* to do in the matter of central station work, and in an interesting paper read before the Institution of Electrical Engineers a few days ago we were told pretty much the same thing by Mr. J. B. Verity with regard to the important question of underground conduits. American experience was, of course, largely referred to, and a variety of ingenious conduit systems were described. Mr. Verity's own preference, so, far as regards high tension work, is for cables insulated with the best vulcanized rubber and run in iron pipes. He incidentally remarked in the course of his paper that he had patented a system of glass tubes in iron pipes, inside which it was proposed to place bare conductors. It is interesting to note in this connection that a somewhat similar idea is being tested on the continent. In this case glass tubes protected by a thin coating of specially prepared cement, are inclosed in cast-iron piping, the iron being run on hot. Great advantages are, of course, claimed for this plan, and if it can stand the racket of practical experience, the possibility of using bare conductors will undoubtedly prove a point in its favor.

Dr. Oliver Lodge on the Discharge of a Leyden Jar.—At the Royal Institution on Friday evening last, before a large and distinguished audience, Dr. Oliver Lodge delivered a most interesting lecture on "The Discharge of a Leyden Jar." The learned doctor is working at this subject with such ardor and enthusiasm that, as your readers will be aware, he comes out with some new and striking experimental discovery almost every few weeks. On this occasion, which I venture to think is likely to rank as an historic one, he demonstrated for the first time in public the possibility of so reducing the rate of electrical oscillation on the discharge of a Leyden jar as to cause the spark to produce a note of definite musical pitch. Under ordinary conditions it is now well known that the discharge of a Leyden jar in a circuit possessing little self-induction gives rise to oscillations having a frequency of of some millions per second. Now there are two methods either or both of which may be adopted, in order to reduce this high rate. In the first place we may increase the capacity of the jar, which practically amounts to the connection of as many jars as may be available, in parallel. Taking the mechanical analogue of a vibrating reed, this corresponds to increasing its length, which has obviously the effect of lengthening its time of vibration. But the same effect will be produced without changing the length of the lath by fixing a weight to its free end. This is the mechanical analogue corresponding to the introduction of self-induction into the electric circuit. Consequently, when we take a large battery of jars and discharge themthrough a circuit containing a very large amount of self-induction, it is possible to bring down the rate of oscillation from some millions to a few hundreds per second. In this case the spark produces a musical note, very similar to the sound which may be produced by sticking a short sewing needle into a piece of wood and twanging it. By making the capacity or self-induction four times larger, we immediately get the octave, which may be taken as a proof of the soundness of the theory. All this was exhibited by Dr. Lodge with the greatest possible success, and caused much enthusiasm amongst the audience. During these experiments, an episode of a somewhat dramatic character occurred. It happens that the wall of the lecture theatre at the Royal Institution is covered with a paper bearing a small pattern stamped in gilt or bronze, and so powerful were the electric discharges which the doctor had at his command that they positively set up induced oscillations upon the wall of the room, which when pointed out were perfectly visible to the entire audience. As soon as the electric lights were turned out it was seen that in many parts of the room sparks, some two or three inches in length, were darting about upon the wall paper in an almost alarming fashion. This unrehearsed effect afforded Dr. Lodge an opportunity of turning round on Mr. Preece, who was sitting in the front row, and pointing out that it was such phenomena as these which led him to hold different views to those of Mr. Preece upon the subject of the oscillatory character of the discharge. The next day Dr. Lodge repeated the experiments at the Physical Society and went more deeply into the theory of the subject.

THE TELEGRAPH.

Baltimore & Ohio.—A certificate of dissolution has been filed in the State of Illinois by the B. & O. Telegraph Company of that State.

The Postal Telegraph Company had a small fire on May 20, in the top floor of its five-story building, 5 and 7 Dey street. The damage done was put at about $3,000. The cause of the fire is not known.

Telegraphers' New Club Room.—Members of the New York Telegraph Club gathered on May 21 at their new quarters at 48 and 50 Church Street, which they expect to open formally June 1 for their quarterly meeting. The new rooms occupy the entire third floor, and are fitted up in old-gold papering and English oak fittings, which give them a very attractive appearance. The rooms comprise a library, a card-room, a reading-room and a billiard-room, with a combination pool and billiard table. The club intends to have a gymnasium and baths on the floor above.

THE TELEPHONE.

Increasing Bell Stock.—The bill increasing American Bell Telephone stock from $10,000,000 to $20,000,000 passed to its third reading in the Massachusetts House on May 21, and then was passed to be engrossed. The bill now goes to the State Senate, where it will be equally well treated.

Can These Things Be?—What the every-day machinist or draftsman doesn't know about electricity would usually make a pretty good size book, and what is more, he knows it. A private letter from a friend, who manipulates a T-square for a well-known firm of tool builders, closes with the following information: "I have got a new office—Electrician for the —— Company. I go round and fill up the batteries of the telephone transmitters, and when they don't work, wonder what ails 'em."—*American Machinist.*

A Long Wire.—The wire belonging to the Western Counties and South Wales Telephone Company, which crosses the entrance to Dartmouth harbor, has the remarkable span of nearly half a mile, viz., 800 yards. On leaving the Dartmouth side the wire is 332 feet above high-water mark; it drops to 198 feet near the Kingswear side, and then rises again to 207 feet. The wire is very fine and light, being of No. 17 silicon-bronze, weighing twenty-four pounds to the span. This line has already withstood several strong gales in a most satisfactory manner.

THE ELECTRIC LIGHT.

Eufaula, Ala.—Two companies have applied for electric lighting franchises.

Bainbridge, Ga.—Mr. W. M. Blount, of Bainbridge, wants electric light apparatus.

Milledgeville, Ga.—The city proposes to issue $50,000 of bonds for electric light plant, etc.

Asheville, N. C.—Mr. W. C. Browning, 1,235 Arch street, Philadelphia, will want an electric light plant for a new hotel at Asheville.

Covington, Ky.—The Citizens' Electric Light & Power Company have purchased the Kenton Electric Light and Power Company.

Marion, O.—Marion Electric Light and Power Company have placed an order with the Schuyler Electric Company for an immediate increase.

Norwalk, Conn.—The Norwalk Gas Co., have adopted the Ball system of electric lighting, and will install a fifty horse power Otto gas engine with which to run the plant.

The United Edison Manufacturing Company has been incorporated in this State with a capital stock of $100,000, by H. Villard, E. H. Johnson, F. R. Upton and others.

The Sheboygan, Wis., Electric Light Company has been incorporated by A. F. Leberman, W. D. Crocker, M. H. Wilgus and D. Gibbs, with a capital stock of $25,000.

The Winchester, Va., Gas Company started a Schuyler arc light plant May 4. The light is in every way satisfactory, and quite an increase will be made in the near future.

Lyons, N. Y.—The Board of Trustees have contracted with the local Thomson-Houston Company for 35 lights of 1,200 c. p. for 3 years, at $2,100 a year. More lights will be taken if necessary.

The Schuyler Electric Company have just installed one of their improved dynamos, with full complement of lamps, in the station of the Anthracite Electric Light and Power Company, Pottsville, Pa.

The Hell Gate Electric Light Tower, which has not been in use some time, on account of the complaints made by navigators against the intense brilliancy of the Brush lamps, is now being pulled down.

The Stamford, Conn., Electric Light Company, using the Schuyler system, have displaced four of the old style regulators with the new improved automatic regulators manufactured by the Schuyler Company.

Alexandria, Va., will be illuminated with the arc light for the first time on July 4th. The Schuyler system will be used. The city has bought 60 double arcs, 120 series incandescents, station equipment, steam plant, etc.

Dansville, N. Y.—Superintendent Randall, of the Dansville Electric Light Company, has a force of men at work erecting wires and lights from that village to the Lackawanna station, about one mile north of the company's works.

Bryan, O.—The Bryan Electric Company have adopted the Schuyler system, and until they can complete their station have made a temporary installation. The light meets with much favor, and an immediate increase is talked of.

The Backstrom Electric Light Company, of New York, has been incorporated, with $50,000 capital. Its trustees are Charles A. Backstrom, Charles Cuns, Andrew H. Lander, Oscar E. Sanger and Adolph Stahlberg. The company has taken offices in the *Times* building.

Anniston, Ala.—The Anniston Gas and Light Company, previously reported as to add an electric light plant, have purchased the plant of the Anniston City Land Company, and will hold a meeting on June 10 to consider issuing bonds to add an incandescent light plant.

Havana, Cuba.—The Spanish-American Light and Power Company, of Havana, Cuba, have completed their new plant, which is now in very successful operation. The power consists of one 13 × 22 × 13 (125 h. p.), and one 10 × 18 × 10 (65 h. p.) Westinghouse automatic compound engines.

Norfolk, Va.—The Norfolk Edison Electric Light and Power Company has been formed with a capital stock of not less than

$15,000, and not to exceed $500,000. Mr. D. Lowenberg is president; Mr. R. B. Tunstall, vice-president; and Mr. C. B. Johnson, secretary. The plant is to be put in at an early date.

Frankfort, Ky.—Mr. Samuel J. Shea, Frankfort, Ky., wants to purchase a plant for the steamer "Grace Morris," consisting of the following: One 5-light (2,000 candle-power) dynamo, one engine suitable to run same, four 2,000 candle-power single carbon lamps, one 2,000 candle-power focusing lamp, wire, insulators, etc.

American Machinery in Spain.—The great "Tarzuela" at Madrid, Spain, which is the largest theatre in the kingdom, has recently introduced a complete installation of electric lighting, under the supervision of Mr. L. Delannoy, mechanical engineer, of Barcelona, a 12 and 20 by 12 Westinghouse automatic compound engine, built at Pittsburgh, being used as the motor.

Providence, R. I.—The city of Providence has authorized the joint committee on lamps to contract for 300 electric arc lights for five years from June 15, 1889. The electric company have accepted a proposition of 44 cents, a reduction of 12 per cent. from the regular price. Four years ago the city council rejected an offer of 33 cents for two years, and the present contract is claimed to be a repetition of the contract which the city of Boston made a few years ago, compelling the city at the present time to pay much more than any other city for its electric lights.

Springfield, Mass.—The Council has passed the order authorizing the Street Lighting Committee to make a new contract for electric lights. It provides that the lights shall burn all night; they are to be arc electric lights of 1,200 standard, and not less than 800 actual c. p. each. The contract is to be for a term of five years, and the price will be $83.33⅓ per light per year. The number of lights will not be less than 300, and as many additional as the city may wish at the same price. The contract will be made with the United Electric Company. There are now 55 electric lights in operation, which cost the city $12,045 a year, or $219 a light. The standard c. p. of the present lights is 2,000, with an actual c. p. of between 900 and 1,200. While the new lights will have but 1,200 c. p., the actual standard will be between 800 and 1,000 c. p.

The Heisler Electric Light Company reports plenty of business and excellent prospects. Their Belton (Tex.) station has just been started and is giving perfect satisfaction. Plants at Port Arthur and London, Ont., and Montrose, Col., are being started this week. The installation of the Heisler plant of 1,000 30 c. p lights at the Paris Exposition is now being completed. Mr. Heisler expects to leave for Paris in a few days to give this exhibit his personal attention. Among contracts recently received is one for lighting the Art Department of the St. Louis Exposition, the lighting of this department by the Heisler Company last fall having proven highly satisfactory. In view of the fact that the Exposition Association has an incandescent plant of its own, and has also experimented considerably with arc lighting, this order is particularly gratifying.

The Norfolk & Western Railroad Company have just erected at Bluefield, W. Va., an electric plant for the purpose of having better yard facilities; there are 21 lights in operation, for that purpose; the dynamo is located in the machine shops of the company, and is run by the same engine that runs the machinery in the shop. The cost of 21 lights will be about 15½ cents per light per night. They have also erected an automatic electric block signal at Elkhorn tunnel, for the purpose of blocking trains while passing through the tunnel, which is about one-half mile long, and on a very heavy grade. They also contemplate attaching an electric signal to their scales at Bluefield, W. Va., where they weigh cars by gravity; the scales have a capacity of weighing 1,000 cars per day, and from these scales are weighed and shipped all the coal and coke mined in this section of Virginia and West Virginia. I learn that an electric plant will soon be erected at Mill Creek, W. Va., for the purpose of lighting up the towns through the mining regions on Elkhorn, Bluestone, and at Pocahontas, Va.

The Westinghouse Electric Company has divided the country into districts appointing in each an agent who is given charge of the selling business throughout his district. This plan of conducting the rapidly increased sales of alternating current apparatus was begun some months ago, and is now fairly under way. The company is now represented in their several districts by the following agents: Wm. A. Carey, 620 Atlantic avenue Boston, Mass.; Henry Hine, 120 Broadway, New York; D. A. Tompkins, Charlotte, N. C.; J. H. Gates, Marshall, Tex.; W. C. Clark, San Francisco, Cal.; Guido Pantaleoni, St. Louis, Mo.; George O. Fairbanks, The Rookery Building, Chicago, Ill.; A. T. Moore, Jr., Denver, Col.; H. W. Goode, agent for the Northwest, has not yet established an office, but will, doubtless, be located at St. Paul or Minneapolis. The Westinghouse Company report the following recent contracts for alternating current and central station outfits: Middleboro, Mass., 750 lights and a 35 arc light outfit; Port Jervis, N. Y., 750 lights; Englewood, Ill., 1,500 lights; Birmingham, Ala., 500 lights; St. Helena, Cal., 500 lights and a 20 light arc light outfit.

APPLICATIONS OF POWER.

Charlestown, W. Va.—The Charlestown Electric Light Company have asked for a local electric railway franchise.

Red Ash, Ky.—Mr. J. M. Wilson, of the Birds Eye Coal Company, wishes to correspond with regard to cost of electric plant to haul coal in mines, lighting mines, and furnishing power for running mining machinery.

Richmond, Va.—The *Manufacturers' Record* says: "The Black's System Company has been incorporated with W. P. De Saussure, president; S. B. Witt, secretary, and Daniel Stephens, treasurer, to operate an electric street railway by underground wires. The capital stock is to be not less than $10,000 or more than $200,000."

PERSONALS.

Mr. I. E. Winslow, a young Brooklyn engineer, has just started the electric road at Bangor, the first in the State of Maine.

Mr. E. H. McFall, with headquarters at the Bell telephone offices, has been appointed agent for the Eddy motor in New Orleans.

Mr. T. C. Frenyear, who represents the Electric Gas Lighting Company of Boston, was a visitor in New York last week taking a brief vacation from hard work.

Mr. Jesse M. Smith, the electrical engineer, of Detroit, left for Europe on the "City of Richmond" on May 25, with the Mechanical Engineers, of which body he is a member.

Prof. Elihu Thomson, will, it is understood, enjoy a brief period of rest and recreation in Europe this summer. He will visit the Paris Exposition, where he will have a personal exhibit additional to that of the Thomson-Houston Company.

Mr. Lewis Searing has sailed for Europe to represent at the Paris Exposition the Geyer-Bristol meter recently described before the American Institute of Electrical Engineers. The meter is entered for the prize of $2,000 offered by the city of Paris.

Mr. S. D. Field, from Stockbridge, Mass., has been in town recently looking after the development of some new ideas, with which, as usual, he is burdened to brimming over. It is said that his recent work in telephony has great promise of a solution of the long-distance problem.

Mr. R. E. Gallaher, the secretary of the New York Insulated Wire Company, is busily engaged preparing another edition of the useful price list which he issued last August. The pamphlet, which contains much information that is handy, has gone out of print. In the new edition it will be enlarged and revised.

Mr. Wm. Maver, Jr., the electrical expert, has just been appointed electrician to the Consolidated Telegraph and Electrical Subway Company of this city. Mr. Maver has been making a special study of the underground problem, and the company is certainly to be congratulated on securing the services of one so able and competent.

John W. Mackay, the Silver King, has been presented by the Silvertown Telegraph Works Company, England, with a handsome glass case containing samples of all the telegraph cables in the world, nicely tipped with German silver bands. In size they range from that of a lead pencil to that of a man's arm. It is a unique and magnificent collection.

Mr. Leo Daft will read a paper before the American Institute of Electrical Engineers on June 18, entitled: "Some Recent Work on the New York Elevated Railroads, and Its Bearing on the Rapid Transit Problem." The paper will be quite elaborate and will in its special and general public bearings be one of the most important ever laid before the Institute.

Mr. C. O. Mailloux, the electrical engineer, has returned to New York from a vacation at Terre Haute, Ind., where he was greatly pleased with the interest shown at the Rose Polytechnic Institute in electrical engineering. Mr. Mailloux availed himself of the opportunity to hear a few of Professor Gray's admirable lectures on dynamic engineering.

Mr. Wm. Hubbard, the general manager of the Elgin, Ill., Telephone Company, has been equipping Dawson, Ga., with telephones, and has also secured about 500 pounds of Andersonville prison relics to show the veteran "boys in blue" on May 30. The relics include the upper part of the stump from beneath which flowed the famous "Providence Spring."

Mr. William H. Bryan, for many years connected with the Pond Engineering Company, and whose specialty was the department of steam plants for electrical service, has identified himself with the Heisler Electric Light Company, and can be found in future at their offices, 309 to 317 S. Seventh street, St. Louis, Mo. He hopes to hear from his friends and others who may be investigating the question of incandescent electric lighting.

Mr. George Westinghouse, Jr., president of the Westinghouse Machine Company and many other corporations, was born in 1846. His father owned and operated works at Schenectady for the manufacture of agricultural implements, and it was there that the boy first showed his marvelous taste and genius for mechanics, beginning, even at that early day, to bring out successful inventions whose object was to do by machinery what had been done previously by hand. He is well known to electrical people from the great impetus he has given to the introduction of alternating currrent apparatus in this country, but it is not so well known that he is also one of the leading spirits in the natural gas industry. His company at Pittsburgh has on its list 30,000 consumers who use the equivalent of 20,000 tons of coal daily.

Mr. H. de Castro.—Some of his history is writen on Hector de Castro's face. He is a bachelor, of course, as all the Worth House men are. The rent of his apartments is said to be $300 a month. He is a thick-set swarthy man, weighing perhaps 180 pounds, and bearing evidence of his Spanish extraction in his smooth olive complexion and heavy black hair, mustache and eyes. Mr. de Castro was a confidential man in one of the Rothschilds' great European houses not so very long ago. He received his financial training in the service of that famous family. John W. Mackay, the bluff miner, who had made his scores of millions and felt the necessity of having help in the keeping of them, went to the Rothschilds and asked them to recommend him a financier in whose ability and discretion he could rely. They recommended Hector de Castro, who is now vice-president of the Mackay-Bennett Cable Company, of which his brother is the London agent.—*New York World.*

MISCELLANEOUS NOTES.

Green Forest, Va.—The Buena Vista Company proposes a long distance electrical utilization of its water power.

The "Electric Sugar" Case is now being heard, the Rev. W. E. Howard, father-in-law of Professor Freund, being on trial in Part I. of the New York Court of General Sessions.

Why Wouldn't "Electrothud" do for the word to express execution by electricity? A thud with lightning in it would be an improvement on the old kind.—*Cincinnati Commercial-Gazette.*

Tanning by Electricity is one of the newest applications in the industries. This comes from the introduction of the electric light into our schools, we presume. The punishments are light, of course.—*Yonkers Statesman.*

The European Railway Signal Company has been incorporated by W. J. Johnson, C. L. Cook, H. L. Hoover and others, at Richmond, Va., for the manufacture and sale of electric railway signals in all countries other than the United States. The capital stock is to be not less than $50,000 nor more than $200,000.

Electrical Executions.—Gen. A. Lathrop, superintendent of New York State prisons, has had a conference with the wardens of Sing Sing, Auburn and Clinton prisons as to the apparatus required for electrical executions. The first execution should take place on June 27, but it is expected that there will be a "stay of proceedings."

Boston, Mass.—Mr. W. B. Darby, cashier of the Mutual District Messenger Company, of Boston, was put under arrest on May 20 on the charge of embezzling $10,000 from the Western Union Company. It is stated that he had made it a practice to raise the amount of the monthly bills of the company against the Western Union Company and pocket the difference.

Canadian Electrical Society—The following are the society's new officers: President, Dr. A. L. Smith (re-elected); 1st vice-president, Mr. Jno. Horn; 2d vice-president, Mr. H. Lampard; secretary, Mr. D. Cameron (re elected); treasurer, Mr. A. Walsh (re-elected); council, Dr. Brown, Mr. M. F. Jannard, Mr. Shaw. There will be a joint paper read by Messrs. Douglass and Shaw at next meeting, on Monday, June 3, on "Dynamos and Motors."

Wiring Calculations.—With regard to his excellent paper on wiring, that appeared in our last issue, Mr. C. E. Gifford says: "In the fourth line, second column ($C \times D$) should be ($C + D$). Also, in the second formula, C should be C'. Those that may contemplate future reference to the article should make these corrections now. These formulæ will give accurate results. The very common method of basing calculations upon the distance between the point of entrance and the supposed centre of distribution, gives results that are only distant approximations."

BUSINESS NOTICES.

Henry R. Worthington has opened a branch office for the sale of his celebrated pumping engines, etc., at No. 338 Sibley street, St. Paul, Minn.

Westinghouse Engines.—During the first twenty-one days of May the Westinghouse Machine Company received orders for sixty-six engines, aggregating 3,375 h. p.

The Electrical Supply Co., of Chicago, are handling a very complete line of electric gas lighting apparatus, which will be found fully illustrated in their new House Goods Catalogue, No. 647, recently issued.

Chas. A. Schieren & Co., New York, are the patentees and sole manufacturers of the perforated electric leather belting. The perforations obviate air cushions; hence belts run slack with less strain on bearings, and without slip.

Patterson, Jordan & Gottfried, 146-150 Centre street, carry a complete stock of brass and iron machine and wood screws, cap and set screws, all kinds of bolts, taps, files, twist drills, brass and rubber tubing, brush copper, rod and sheet copper, brass rod, sheet German silver, sheet brass, machinery, tools, hardware, etc. Electric motor supplies.

To Investors.—A Chance for Electric Power.—A valuable water-power franchise suitable for developing electricity is offered for sale in a rich mining district, over 200 horse-power; can be sold at once in units varying from 5 to 50 h. p. within a radius of one mile from generating station. Address for particulars, Electric Mining, P. O. Box 2,382, Denver, Colo.

The Fitchburg Steam Engine Company have just issued a special circular relating to electric lighting. This is made up in a compact form and contains much valuable information. The company are doing a large business in electric light work and are prepared to give estimates on complete plants, condensing, compound condensing, or otherwise. The circular is sent free to any address.

Patent Fire Felt.—The new asbestos pipe and boiler covering, recently put upon the market by the Chalmers-Spence Company, New York, is meeting with pronounced success, and is being generally adopted where a thoroughly reliable non-conducting, water and fire-proof material is need for covering purposes. For electric lighting stations it is looked upon with especial favor. In this connection, we are informed that the Chalmers-Spence Company have just completed a contract for covering pipes at the new stations of the Edison Electric Illuminating Company, of this city, one of which is located at Twenty-sixth street, and the other at Thirty-ninth street. The materials used were their patent fire felt covering for steam pipes, and the same material as supplied in sheet form for drums, heaters, etc.

The New York Belting and Packing Company.—The Chicago representatives of the New York Belting and Packing Company, Messrs. W. D. Allen & Co., have just issued a new and attractive catalogue, containing descriptions of a full line of vulcanized rubber goods, including belting, packing and hose. The cover in buff tint is very attractive, and is printed in red and bronze. A view of the company's extensive warehouse and salesrooms, 151 Lake street, is shown on the back. It is a pamphlet of forty pages, profusely illustrated, typographically correct in every particular, and great care and much labor have evidently been bestowed on its preparation and production. Its possession cannot fail to be of benefit to those interested in the line of goods which Messrs. W. D. Allen & Co. handle. Messrs. Allen & Co. also represent the famous Hoyt leather belting at Chicago.

The Hibbard Electric Manufacturing Supply Company, Limited, 773 Craig street, Montreal, have issued a remarkably large and handsome catalogue. The company was formed not long ago to acquire the business established by Mr. W. C. Hibbard and carried on by him with much success during the past few years Mr. Hibbard remains with it as managing director. In order to cope with the growing volume of business, the company have erected a large and commodious factory and fitted it up with the best and latest machinery, and they propose to fill orders for all kinds of electrical goods with the utmost promptitude and as well as they can be executed in any other part of the world. Hitherto little has been heard of Canada in the line of electrical manufactures, but the company promise a new departure, and are evidently well equipped to keep their intentions. The catalogue is about 120 pages, and is very handsomely printed and illustrated.

Beck Engines for Electric Lighting.—Recent sales of "Beck" automatic engines and complete steam plants for electric light and power service are reported by the Taylor Manufacturing Company, of Chambersburg, Pa., as follows: One 11½ by 15 inch automatic engine to the Edison Light and Power Company, of La Crosse, Wis., making the third engine to this company: one 13 by 15 inch automatic engine and 60 inch by 16 foot boiler, complete, to the Greenville, Miss., Electric Light and Power Company, making the second complete steam plant installed for this company; one 11½ by 15 inch automatic engine for the American Bridge and Iron Company, of Roanoke, Va.; one 15 by 18 inch automatic engine and 150 h. p. boiler, complete, to Merchants' Electric Light and Power Company, of Birmingham, Ala., making the second complete steam plant that they have sold for operating central stations in Birmingham; one 12½ by 15 inch automatic engine and 66 inch by 16 feet boiler, complete, to the Washington, Pa., Electric Light and Power Company; one 10½ by 12 inch automatic engine and 50 inch by 16 foot boiler, complete, for Piedmont, W. Va., Electric Light and Power Company; one 9½ by 12 inch automatic engine to Edwin G. Klose, Philadelphia, Pa., for electrical service; one 11½ by 15 inch automatic engine to the Keystone Wall Paper Company, of Philadelphia; one 12½ by 15 inch automatic engine to the Coal Department of the Union Pacific Railroad Company, to go to Rock Springs, Wyoming, for operating electric light plant; one 14½ by 18 inch automatic engine and two 80 h. p. boilers, complete, for Thomson-Houston station at Bedford, Pa.; one 12½ by 15 inch automatic engine, through their Boston branch office, for electric light service; one 11½ by 15 inch automatic engine and 72 inch by 16 foot boiler, complete, for Bryan Electric Company, of Bryan, O.; one 7 by 8 inch automatic engine for steamer "Kate Adams," operating dynamo; one 10½ by 12 inch and one 12½ by 15 inch automatic engines and two 56 inch by 16 foot boilers, complete, to Oppermann Electric Lamp Manufacturing Company, of Plattsmouth, Neb.; one 12½ by 15 inch automatic engine and 60 inch by 16 foot boiler, complete, for Roanoke, Va.

Owing to the pressure on our columns, the Patent Record has been omitted this week.

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